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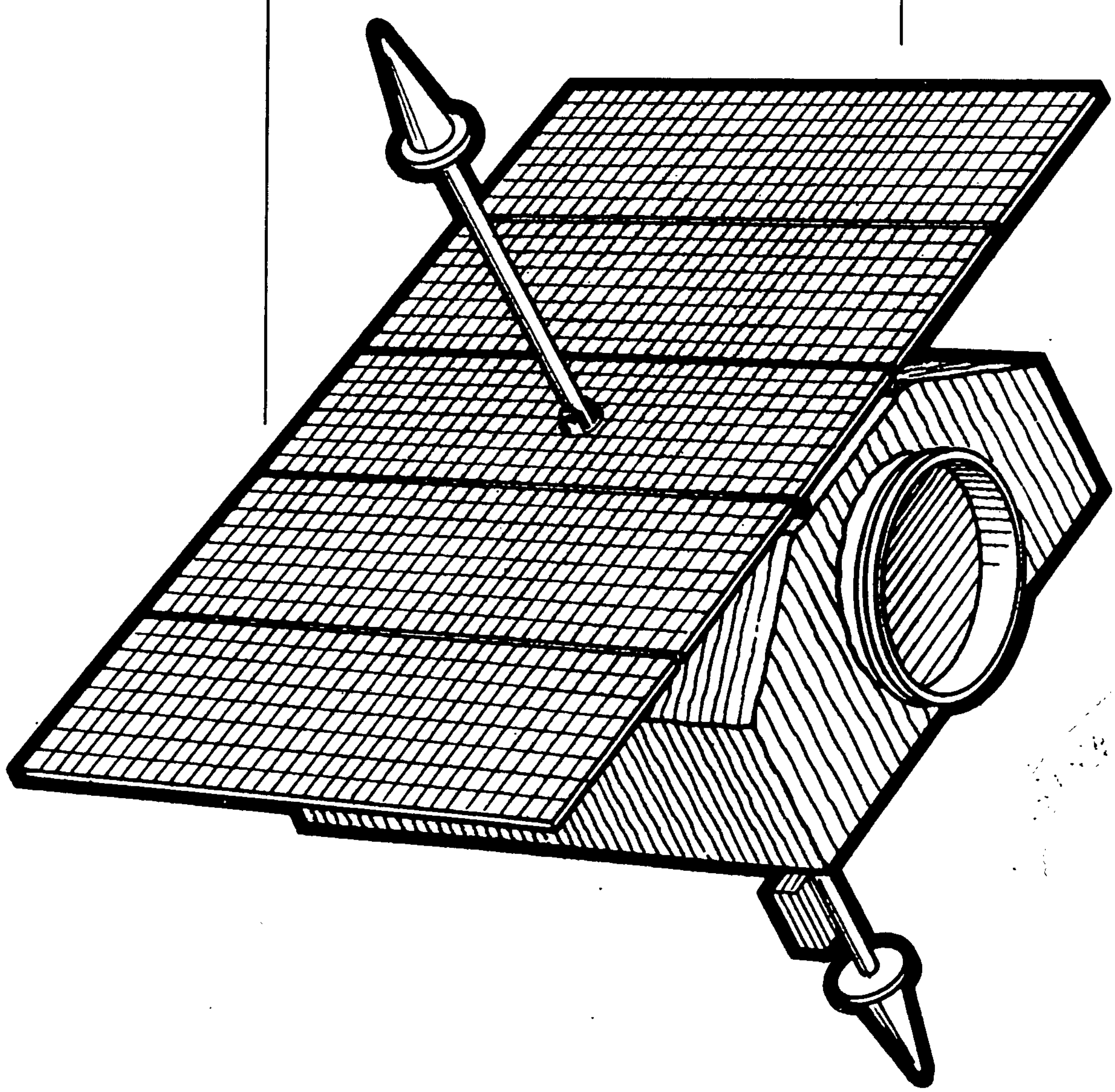
FEASIBILITY STUDY OF THE BOEING SMALL RESEARCH MODULE

NASA-Ames Research Center
Advanced Space Projects Offic

Boeing Aerospace Company
Space Systems Division



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FINAL REPORT

FEASIBILITY STUDY OF THE BOEING SMALL RESEARCH MODULE (BSRM) CONCEPT

NAS 2-8526

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FOREWORD

This document is one of a series of four (4), describing the design, manufacture, and management of the Boeing Small Research Module (BSRM). The documents constitute the final report of Contract NAS2-8526, "Feasibility Study of a Small Research Module Concept," performed for the Advanced Space Projects Office of NASA-Ames Research Center.

The objective of the study was to define a low cost standardized spacecraft combining an existing spacecraft design with USAF Space Test Program (STP) management control and NASA aircraft program (ASSESS) instrument integration techniques. The results of the study, presented in this set of documents, includes a preliminary spacecraft design; plans for the management, development, manufacture, test and operation of the spacecraft; and rough order of magnitude (ROM) costs.

The four documents included in this final report are:

D180-18450-1	Executive Summary
D180-18450-2	BSRM Design Document
D180-18450-3	BSRM Program Definition CR-137663
D180-18450-4	BSRM Program Costs

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1.0 INTRODUCTION AND SCOPE

This document contains the schedule and preliminary plans for the BSRM Program Definition in accordance with Statement of Work Task 6.4 in NAS2-8526 study contract. The plans describe various aspects of a BSRM Program consistent with the low cost approach utilized by Boeing on many successful USAF satellite programs. Specifically, the plans were compiled from approved plans from the Burner II/IIA, SESP P70-1, STP P72-1, and S3 programs.

In preparing this document, the retention of low cost program features was paramount. No attempt was made to conform to NASA procedures, specifications, or methodologies not compatible with existing practices used by Boeing on USAF programs. By using existing plans, procedures, design and fabrication techniques, off-the-shelf equipment items, released design analyses, and other existing documentation, the BSRM Program can be implemented with a minimum of coordination resulting in a quick response schedule and low cost. The documentation which can be used directly or with minor revision for BSRM includes the following:

- o Numerous approved plans contained in this document.
- o Applicable CDRL submittals such as range safety documentation, qualification data, design criteria, etc.
- o Applicable design analyses not affected by the experiment mix such as communication link analyses, EED analysis, and some subsystem analyses.
- o Numerous procedures for operation of the Test Data Van, subsystem demonstration tests, TM calibration, magnetic survey, EMC/EMI acceptance, etc.
- o Software programs for attitude control and attitude determination.
- o Complete procurement specifications for all off-the-shelf hardware.
- o Complete data packages from suppliers for qualification verification, reliability, and performance for all off-the-shelf hardware.

The BSRM schedules included herein are based on implementing the program described by these plans. The schedules are consistent with previous Boeing experience on USAF low cost spacecraft programs similar in size and scope to the BSRM.

It is contractor's intent that the plans contained in this document would be reviewed, coordinated, and approved prior to initiation of a BSRM hardware contract. These plans would thus form the basis for the conduct of the BSRM mission defining the groundrules for various aspects of the program. In this manner, major programmatic features of the spacecraft development, test and operation would be defined at go-ahead insuring a high confidence in proposed costs, schedules, and reliability.

2.0 MISSION INTEGRATION PLAN

The mission integration task utilizes existing concepts and methodologies developed by Boeing through extensive experience on numerous Burner II/IIA and STP programs. Booster integration for BSRM will be nearly identical to previous tasks successfully completed for Thor and Atlas missions. Experiment integration is similar to the S3 program; the number of experiments, agencies, and Principal Investigators are comparable. Existing plans and documentation will be refined for adaptation to the BSRM program to minimize integration costs.

The heart of the mission integration task is the System Master Integrated Schedule. This schedule will be prepared at the beginning of the BSRM program to identify major program milestones for each participant including experimenters. The type of milestones to be tracked include the following:

- o Major program events such as design reviews, deliveries, test completion, drawing releases, launches, etc.
- o Spacecraft program design, fabrication and test schedules, CDRL submittals, experiment and booster ICD approvals, delivery, launch and post flight activities.
- o Booster contractor interface functions, interrelated CDRL submittals and ICD approval.
- o Experimenter interface functions, ICD approvals, payload deliveries, experiment integration tests, launch and post-launch support.
- o Government participation including GFE data and hardware requirements, design approvals, ICD and CDRL approvals, and acceptance dates.

The Master Schedule will also show major meetings and responsibilities. This schedule will be developed to the detail used on previous USAF programs and will be updated monthly.

2.1 PROGRAM ORGANIZATION AND CONTROL

Boeing will interface with all participating organizations as required to plan and monitor the overall BSRM program and advise NASA of program status and unresolved problems. The program organizational structure and general areas of responsibilities are shown in Figure 2.1-1.

2.1.1 MANAGEMENT

This Mission Integration Plan is the primary management tool to control the mission integration task. The plan will be updated by Boeing using techniques and background developed for similar programs to provide good management visibility of all program tasks, responsibilities and interfaces for BSRM.

2.1.2 PROGRAM MEETINGS

Boeing will provide contract and program status at monthly Technical Management and Program Status (TM/PS) Reviews. The contractor will participate in other program reviews and meetings as required. The results of these meetings and action item status will be reported at the TM/PS reviews.

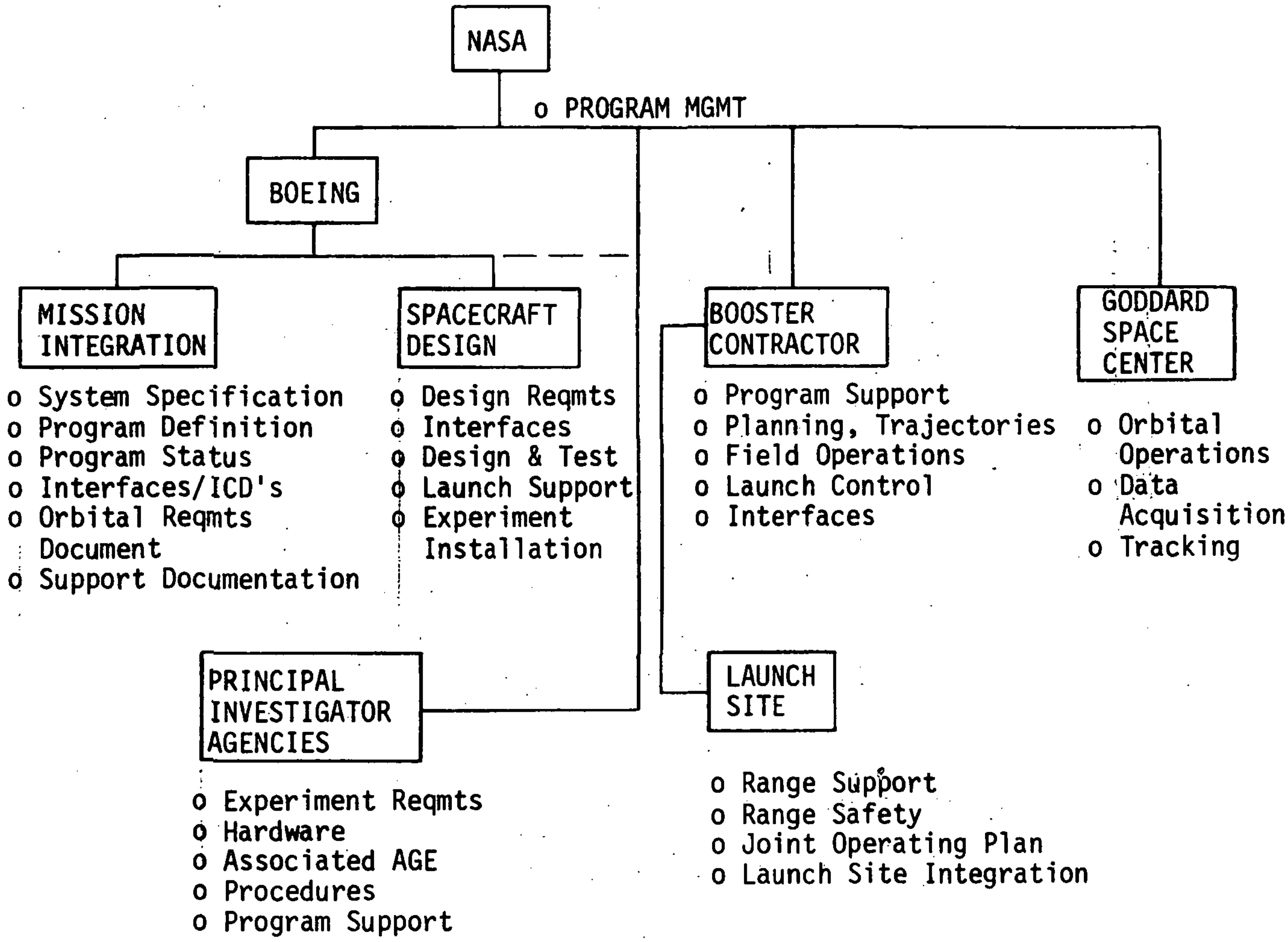

FIGURE 2.1-1: PROGRAM ORGANIZATION

2.1.3 INTERFACE CONTROL

The contractor will meet with the Experiment Contractors and Agencies immediately after contract go-ahead to refine the data required for Interface Control Documents. Any "TBD" items will be assigned dates and responsibilities for resolution. Contractor will prepare a single ICD encompassing all experiments with separate Appendices to detail the peculiar requirements of the different experiments. The basic ICD will be approved by the contractor, all experiment agencies/contractors and NASA. The Appendices will be approved by the contractor, the affected experiment agency/contractor and NASA. Drawings and documents

referenced in the ICDs will be specified by exact date and revision. Proposed changes to the ICDs will be submitted by the originator to NASA and affected agencies/contractors for review. Approved changes will be incorporated as revisions to the affected ICD by the contractor after securing approval signatures. Class I changes will, in addition, be processed in accordance with the contractor's Configuration Management and Change Control plans.

2.2 PAYLOAD INTEGRATION

The tasks and interfaces required for integration of the experiments are shown in Figure 2.2-1.

The contractor will coordinate, prepare and maintain the interface, planning and procedural documentation, and accomplish the testing required to verify that the experiments are ready to support the mission objective. Early activity will be directed to definition of experiment/satellite interfaces, payload design requirements and interfaces and a baseline design. Further activity will include development, integration and test of the total system and definition of requirements, plans and procedures to support the operational mission. The contractor will have responsibility for coordination, integration and documentation of experiment facility, support and service requirements for the launch sites.

2.3 BOOSTER INTEGRATION

The mutual support and division of responsibilities between Boeing and the booster contractor in assuring compatibility between the booster and the spacecraft are shown in Figure 2.3-1.

Boost phase trajectories will be developed by the booster contractor using a Boeing supplied weight model. Using Boeing mass-stiffness data the booster contractor will also perform vehicle stability and control, loads and aerodynamic heating analyses to verify booster compatibility with the BSRM trajectory. Boeing will perform analyses of satellite separation, and of satellite capability to withstand the boost environment. These analyses will be supplemented by testing including model survey and static loads and acoustic/vibration tests. These analyses and tests will verify mission capability and booster interfaces. Boeing will provide interface data as required and the booster contractor will provide Boeing with open and closed loop and design trajectories and dispersions and other data required to perform analyses. The interfaces will be verified by a combined booster/satellite test at the launch site.

2.4 LAUNCH SITE INTEGRATION

Launch site integration tasks will include defining interfaces and facility requirements. Boeing installed AGE, interface/installation drawings, processing space requirements, schedules and umbilical requirements will be prepared by Boeing with experimentor support. These will be coordinated by Boeing who will provide launch site data and interfaces. The booster contractor will

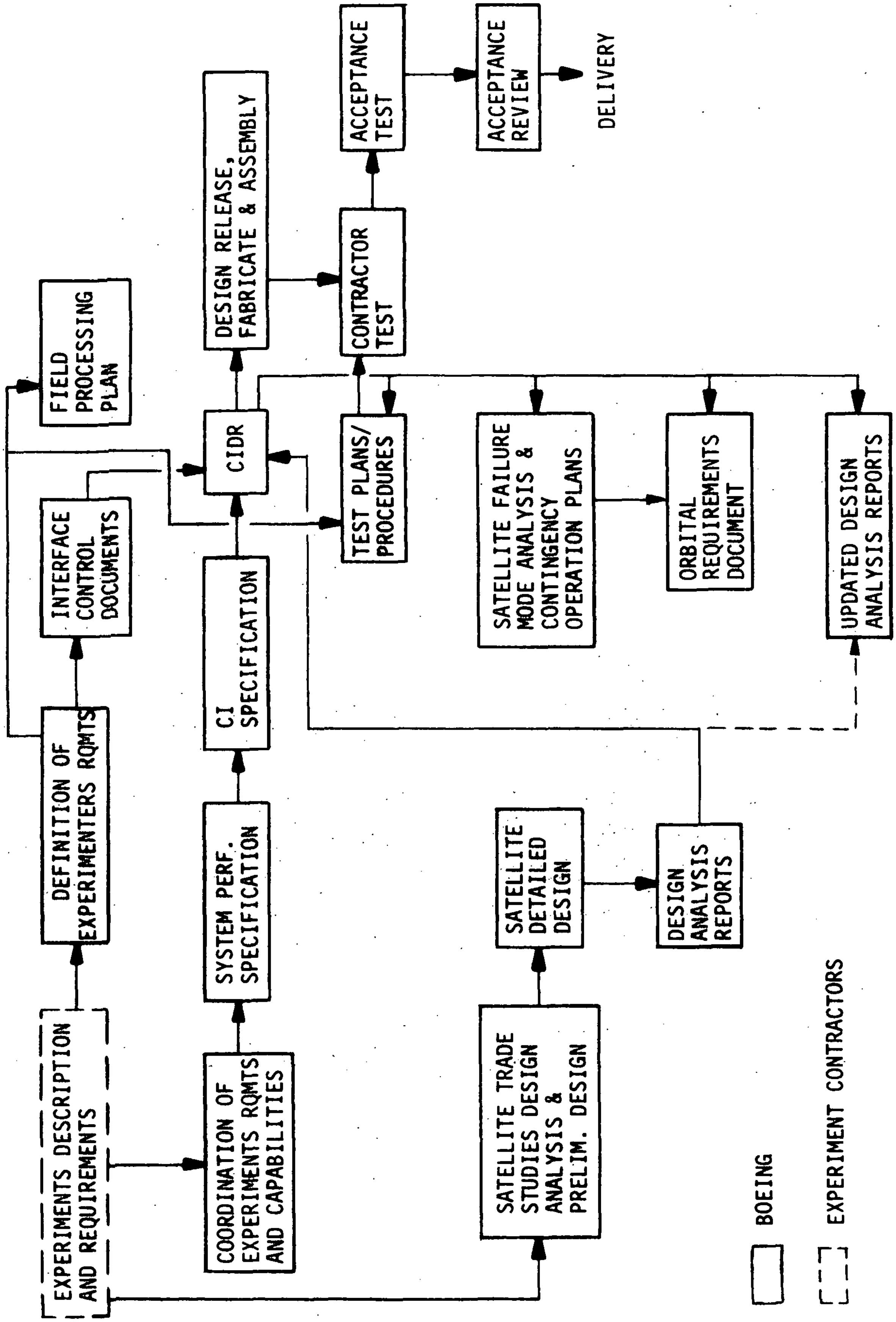

FIGURE 2.2-1: PAYLOAD INTEGRATION

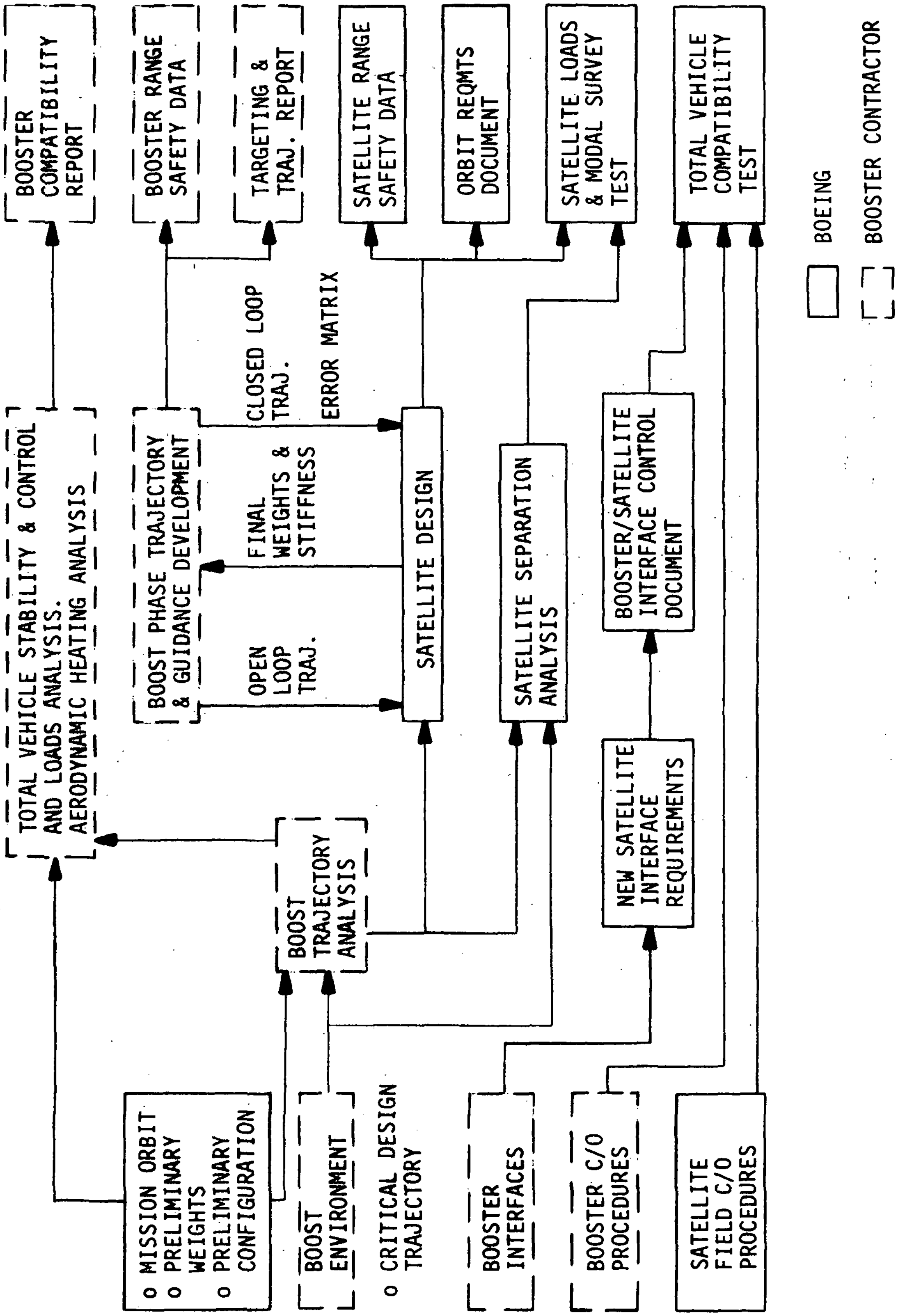

FIGURE 2.3-1: BOOSTER INTEGRATION

establish space allocations and installation schedules and perform configuration control.

Boeing will prepare a Field Processing Plan including experimentor inputs. This will be used to prepare a Joint Operating Plan for range planning, support and scheduling. Launch site coordination of procedures, countdown and schedules will be the responsibility of the booster contractor with support from Boeing and the experimentors.

3.0 QUALITY ASSURANCE PROGRAM

3.1 RELIABILITY/MAINTAINABILITY PLAN

This Reliability/Maintainability Plan defines Boeing's reliability and maintainability program for the BSRM. The plan provides for an integrated reliability program during design, manufacture, and test to achieve the designed-in reliability and maintainability potential ensuring that the delivered satellites satisfy R/M requirements.

3.1.1 SCOPE

This plan identifies those program elements including establishing allocated reliability requirements, types of analyses, and controls necessary to ensure that the BSRM satellites are capable of satisfying or exceeding reliability and maintainability requirements.

This plan applies to all BSRM equipment except for payload GFE and other GFE. The remove and replace time requirement for all modules and black boxes does, however, apply to all GFE payloads.

The application of these program elements to each satellite subsystem of component is determined by the use, complexity, and history of the equipment. Discrimination is made between flight-proven equipment and new design. Thus, where flight-proven equipment is selected, reliability evaluation and verification depend upon past performance, including qualification test data, problem identification and resolution, design improvements, and manufacturing/ quality controls. New or modified design is subject to more extensive evaluation.

This plan is based on the existing S3 Reliability/Maintainability Program Plan. The program elements will be applied to all satellite subcontractors, and a subcontractor reliability program commitment will be required by inclusion of the basic R/M requirements in the procurement specification. However, existing S3 data and/or analyses will not be duplicated for BSRM if the R/M intent and requirements are satisfied.

3.1.2 OBJECTIVES

The objective of the reliability and maintainability program is to ensure a successful program and deliver BSRM satellites which meet or exceed the requirements of the statement of work. This objective will be achieved by:

a. Including the reliability and maintainability parameters in all design considerations (such as trade studies, component selection) on a timely basis.

b. Reviewing and approving the design prior to release to ensure compliance with requirements.

c. Demonstrating by analysis that the BSRM satellites satisfy reliability requirements.

d. Providing management visibility of current Reliability/Maintainability Program status to facilitate direction and control.

e. Providing for active coordination with related activities affecting the reliability and maintainability of the system during its life cycle, including systems analysis, human engineering, and environment control.

3.1.3 PROGRAM MANAGEMENT AND CONTROL

It is the policy of Boeing Aerospace Company to conduct a planned and organized approach to reliability and maintainability on each product program. Company Policy No. 4E1, "Product Safety, Reliability and Maintainability," which requires compliance by all company organizations, defines requirements for the programs to be established by division managers and for developing the technology necessary for sustaining the capability to meet the program objectives.

3.1.3.1 Program Management. The Reliability/Safety and Configuration Control organization, reporting to the program manager, is responsible for implementation of the R/M Plan and has the authority to establish requirements and procedures. This organization, with staff support by the Aerospace Group organization, will:

a. Implement the reliability/maintainability program and provide and maintain procedures as required.

b. Apportion reliability requirements.

c. Update and monitor reliability requirements to reflect design changes.

d. Perform reliability/maintainability analyses.

e. Coordinate the reliability/maintainability program implementation with affected organizations.

f. Review and approve equipment qualification data package for reliability compliance.

g. Evaluate the design and/or test plans and procedures to identify reliability problem areas; participate in design reviews and in design change reviews as a prerequisite to reliability approval.

h. Approve all specifications and drawings (including changes) to indicate compliance with reliability and maintainability requirements.

i. Evaluate test results for reliability achievement.

j. Evaluate supplier reliability analyses and monitor supplier reliability/maintainability task accomplishments.

k. Provide customer and contractor management with reliability/maintainability status reports.

l. Review "Suspect Material Deficiency Reports" supplied by the customer and determine action required.

m. Prepare R/M data reporting and failure summary reports.

n. Prepare "Notification of Defective or Inadequate Parts/Specifications."

The BSRM Reliability/Safety and Configuration Control organization is a focal point for all reliability/maintainability activities, with direct access to all organizations to ensure compliance with program requirements. The task descriptions detail the relationships between this group and other engineering organizations.

<u>3.1.3.2 Control and Coordination</u>. The R/M Plan and the procedures for application are approved by the program manager, providing for management direction and control of the program. The Reliability/Safety and Configuration Control organization is responsible for control of the R/M program and coordinates and monitors the reliability and maintainability activities of all other organizations, to assure proper implementation of the plan.

A primary management control in assuring a successful program is early identification of technical problem areas. During the program, satellite equipment anomalies and failures will be reported, analyzed, and corrected, as discussed further below.

Specific areas of coordination, with closely related program elements, include:

a. <u>System Safety</u>. System Safety and Reliability personnel use the same data for review of failure modes that generate hazards and cooperate in failure reporting where potential safety problems are indicated.

b. <u>Quality Control</u>. Reliability personnel will use the existing S3 procedures and coordination channels for early identification of failures and problems during manufacturing, test and field operation.

c. <u>Logistics</u>. Reliability personnel will provide equipment failure data as requested to assist in the selection of long lead items for potential equipment repair. The methods of packaging, shipping, field handling, and storage will be reviewed to ensure that operational reliability will not be degraded.

d. Staff Support. The Aerospace Group Product Support Engineering organization will provide staff support, specialist services and data as required to support the BSRM program.

3.1.4 PROGRAM REQUIREMENTS

Reliability and related design activities will be accomplished as an integral part of the BSRM satellite design process. The BSRM satellites shall be designed to satisfy the following reliability requirements:

a. The satellites shall provide the necessary support functions to all payloads for the mission period of 180 days with a reliability of 0.80 or greater.

b. The design operating lifetime of each satellite shall be taken to mean not less than 180 days of orbital flight.

c. Each subsatellite with its associated equipment shall be designed so that the booster interface function shall have a reliability (estimate) of 0.9990 or greater. Interface elements shall be designed to adhere to the "no single point failure" criteria.

d. All satellite system designs shall, as a design goal, avoid single point failure modes within weight, power, and other subsystem constraints.

3.1.5 RELIABILITY MODEL

The system reliability models that are mathematically and functionally representative of the mission will be expanded and updated. These models are the bases for all quantitative reliability analyses conducted to show compliance with the requirements. Constituents of these models are mission/phase operating profiles (such as duty cycles) for each equipment item; mission/phase environmental profiles for each equipment item; and functional relationships between equipment and subsystems. The detail of the models will expand as the satellite design develops, and the current models will be contained in the R/M allocation, assessment and analysis reports. All GFE payload functions are excluded from the model.

All failure rates, MTBF's, probabilities, and reliabilities used in the reliability models are those to be associated with the orbital operating environment. Existing S3 data will be used extensively.

Generally all electronic equipment (parts and nonredundant components) are assumed to have exponential lifelength distributions. Consequently, the time of operation of the item and its operating failure rate determine the reliability.

It is further assumed that certain of the failure mechanisms contributing to the unreliability of an item occur at different rates during "off" periods. Thus, an "off" failure rate will be utilized with the appropriate duty cycle when calculating the mission reliability.

The environmental effects associated with launch and satellite injection will be accounted for by utilizing an environmental adjustment factor based on previous experience.

Electronic equipment design will be based not only on the selection of high reliability components but also on the application of conservative stress levels. When applicable, the ratio of these stress levels to rated strength shall be used, together with other factors mentioned above (environmental, duty cycle, non-operating) for determining part failure rates used in the equipment reliability prediction analysis. Boeing Aerospace Company Design Manuals contain stress ratio/failure rate data for basic electronics parts and additional data are available from the Staff.

Some equipment operates in cycles (such as squibs, relays, and switches). This equipment will be described either by binomial lifelength distributions or by exponential distributions in which the failure rate is expressed in failures per cycle and the time parameter is replaced by cycles per mission.

Another basic distribution used as a basis for determining component/part reliability is the normal distribution. An example is a battery cell whose life, in terms of charge/discharge cycles (for given temperature and depth of discharge), is expressed as a normal distribution. In some cases both a cyclic probability of failure (success) and some long-term "random" failure rate (exponential distribution) are ascribed to a device. This latter consideration is made where the cycling rate is relatively low and where pertinent failure mechanisms can occur in the prolonged periods between cycles.

Once appropriate lifelength distributions have been determined for the satellite subsystem components, logic equations can be derived relating individual success/failure to subsystem success. These equations will account for all subsystem redundancies whether operating, stand-by or switched.

3.1.6 RELIABILITY ANALYSES

This section describes the various reliability analyses that will be performed in support of the BSRM satellite design and demonstration.

Allocation - The mission numerical reliability requirement of 0.80 will provide the basis for allocations down to the subsystem and component level. The allocations will be made only to the hardware level necessary to control the design and assure meeting the overall requirement. The initial allocation considered the complexity of the equipment, reliability data of identical or similar equipment, environmental conditions, redundancy and mission profile. These allocations serve as the basis for supplier specification requirements. Existing S3 allocations will be retained where appropriate.

Prediction - A predicted reliability will be calculated for each satellite, less payloads, using the reliability models developed. This prediction is the reliability of the satellite to support the payloads for a period of 180 days after satellite separation from the host vehicle. This considers operational sequence, uses historical success/failure data adjusted for environmental

conditions and duty cycles. Reliability block diagrams and corresponding mathematical expressions will be modified, extended to lower levels and updated as the design is developed. Failure rates will be derived from sources most appropriate for the items involved. The data used, with the source identified, will be shown in the R/M allocation, assessment, and analysis reports.

These predictions, compared with the allocated reliabilities, provide the basis for review and appropriate corrective action, and are used to show compliance with overall mission reliability requirements. The predictions will be presented at the CIDR and will be documented in the R/M allocation, assessment, and analysis report, which will be updated as required to reflect further design definition and possible design changes.

Failure Mode and Effect Analysis (FMEA) - A satellite FMEA will be performed to analyze potential failure modes of the component functional connection to identify potential improvements which could reduce or eliminate adverse effects on mission success. The FMEA will be performed at the component functional input-output level and will use existing S3 analyses extensively.

Reliability/Design Trades - Reliability trade studies will be conducted if it becomes evident that the design may not meet the reliability requirements. Reliability personnel will also assist Engineering in evaluating alternate configurations and equipment functions to ensure that reliability requirements are achieved and to uncover areas for possible reliability improvement. Environmental conditions, time of operation, functional performance limits, safety margins, and redundancy are candidate factors to be considered in the trades.

3.1.7 RELIABILITY CRITICAL ITEMS

The BSRM satellite will be typically a "single thread" design because of weight constraints. Therefore, the satellite components are classified as reliability critical. Any special requirements and precautions to assure no degradation of reliability shall be identified in the applicable engineering drawings, test plans and procedures and thereby will be monitored by Quality Control and Test personnel.

3.1.8 RELIABILITY TESTING

Tests performed solely for the purpose of obtaining reliability data will not be required. However, the Reliability organization will closely monitor all test requirements, procedures and results to assure the adequacy of the test and that causes of failures are identified and corrective action is implemented to preclude recurrence. The procedure for failure reporting and analysis is described in paragraph 3.1.11 of this plan.

3.1.9 MAINTAINABILITY

Maintainability design criteria will be included in the contract item specifications. In brief, these criteria cover provisions for: accessibility and clearances; interchangeability; limiting special tools and support equipment; no

scheduled maintenance as a goal, ease of fault detection and correction; elimination of possibility of incorrect connection, assembly, or installation.

The satellite design goal will be such that all modules, "black boxes," and GFE payloads are readily accessible and may be removed and replaced within 24 hours.

The BSRM maintenance concept is that no maintenance or repair shall be performed on the satellites after installation on the launch vehicle. Any repaired components to be reinstalled in the satellite prior to delivery are to be in the "as new" condition.

The designer is responsible for the inclusion of applicable requirements in the specifications and for designing the system. The maintainability specialist will: review the design for application of the criteria and compliance with the requirements; guide the designer to achieve compliance; assist in the solution of maintainability problems.

Estimates for times to replace components and payloads have been developed for S3. As the design of each BSRM satellite progresses to the point where packaging and installation method are firm, these estimates will be reviewed. Any item exceeding the 24-hour criteria will be reported. Items showing significant differences from the estimates will also be brought to the attention of Engineering.

3.1.10 DESIGN REVIEWS

Design Reviews - Reliability and maintainability specialists will participate in the CIDR and other in-house design reviews. Results of analyses, studies, and reliability/maintainability program activities appropriate to the design will be presented and evaluated as a part of the review.

Continuous Design Reviews - Informal reviews between equipment designers and reliability/maintainability personnel will be held during design development to assure specification compliance and assist in the design decisions.

Monthly Reviews - The R/M Program Status Report and the R/M Failure Reporting and Feedback Failure Summary Report will be summarized and presented as a part of the Monthly Reviews. The reports will be included in the minutes of these meetings.

Qualification Data Review - Reliability personnel will review and approve the summarized qualification data. This data will substantiate the method of qualification of each item. This data will be reviewed for completeness and acceptability of the item to meet specification requirements.

3.1.11 FAILURE REPORTING, ANALYSIS AND CORRECTIVE ACTION

The required actions for the failure data collection, analysis and corrective action will be implemented by the existing Aerospace Group operating procedures. The procedures provide an Integrated Record System to control the recording of

all data associated with assembly, inspection and test of Boeing built hardware and inspection and test of supplier hardware which has been accepted. All anomalies, discrepancies and failures are recorded by this system.

A failure is defined as the hardware being unable to perform within the minimum design requirements at any level of test subsequent to initial Quality Control acceptance.

A report of each failure is required as follows:

a. Suppliers will provide failure reports as discussed in Section 3.3 of this plan. The data required is the same as below.

b. Boeing prepared reports will utilize the "Unplanned Event Record" (UER) which is part of the Integrated Record System. The extent of completion of entries on this form depends upon the place of failure or point on the manufacturing or use cycle. The following data elements or equivalent are required on failure reports:

    1. Report number
    2. Reporting contract
    3. Work center/department (either)
    4. Failed item part number
    5. Failed item serial number
    6. Failed item manufacturer
    7. Date of failure
    8. Activity during which failure occurred or was first detected
    9. Narrative description of failure
    10. Prepared by (name)
    11. Analysis of discrepancy
    12. Corrective action to prevent recurrence
    13. Effect on reliability
    14. Indication of disposition, i.e., close-out of reports

    Space for additional description data is normally included on the failure report form to facilitate processing.

<u>3.1.11.1 Failure Analysis.</u> The following actions, as necessary, will be taken to determine the cause of failure:

a. Inspection of the failed hardware.

b. Analysis of available design data, failure reports, test log, and performance histories.

c. Duplication or simulation of conditions under which the failure occurred.

Failure analysis is conducted at the lowest suspect level, normally the component level. Physics of failure analysis will be conducted to the level required to determine the primary cause of failure.

3.1.11.2 Corrective Action. The cause of each failure will be determined either by inspection or testing of the failed hardware or by analysis of available design data, failure reports, and test results.

All failures will be studied by the contractor, and corrective action will be determined for the prevention or reduction of similar failures. Such corrective action may include, but is not limited to:

a. Design change.

b. Procedure change.

c. Review of test, inspection, or maintenance requirements.

d. Revision of handling or storage requirements.

Quality Control and the Reliability/Safety and Configuration Control organization will monitor the prompt processing of corrective action. Determination of corrective action is undertaken immediately and considered outstanding after 7 days. Outstanding requirements for corrective action will be included in Reliability Status Reports and internal reports for management meetings.

The Engineering organization is provided with copies of all failure reports affecting design. These reports are open until disposition by Engineering allowing Quality Control to close out the reports. All failure reports are routed back to Engineering to alert the designer to problem areas and to obtain design correction where necessary.

The Reliability/Safety and Configuration Control organization is provided with a copy of all failure reports to evaluate the effect on reliability and effectiveness of corrective action.

3.1.11.3 Failure Summary Reports. The failure reports will provide the basis for preparation of a failure summary report. This report will consist of supplier and Boeing significant failures. Significant failures are those satellite equipment failures occurring during acceptance, qualification, and system test, having a potential of affecting mission reliability. Except, failures caused by test personnel error, test equipment anomalies, or test operating procedure faults will not be included in Failure Summary Reports; however, all failure report and corrective action records of the Reliability organization shall be available, upon request, for customer review.

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3.1.12 SUSPECT MATERIAL DEFICIENCIES

Suspect Material Deficiency Notices transmitted to the BSRM program by the customer will be reviewed for applicability. If the suspect material deficiency notices apply to BSRM equipment, responses will be prepared and submitted to the customer.

The customer will be notified by telephone within three days after usage has been determined and a formal report will be airmailed within 21 days after usage has been determined. Material Suspect Deficiency Notices transmitted by the customer to the contractor for information only will be reviewed for applicability and will be summarized in the Reliability Status Report upon conclusion of the investigation. In all cases, the customer will be notified if it has been established that the Suspect Material Deficiency Notices relate to BSRM satellite equipment.

3.1.13 NOTIFICATION OF INADEQUATE PARTS/SPECIFICATIONS

Inadequate parts/specifications notifications will be prepared as required for BSRM satellite parts. Reports will be written for parts which were accepted as meeting procurement specifications, MIL specifications, or were qualified vendor parts which have suffered repeated failures, or failures which have a critical impact on the program.

An initial notification will be transmitted to the customer by telephone no later than three days after discovery, followed by a formal report within 30 days after discovery.

3.2 PARTS CONTROL AND STANDARDIZATION

The selection of parts, materials, and processes is controlled and approved by the Reliability/Safety and Configuration Control organization to ensure that the selection satisfies reliability requirements. Existing S3 program parts, materials and processes will be used extensively. The selection of specifications and standards will be in accordance with MIL-STD-143 except as follows:

a. All electronic parts/devices shall be screened in accordance with MIL-STD-883, Method 5004 Class B for micro-circuits and MIL ER (level R or better) or JAN TX for parts other than micro-circuits.

b. Military standards parts devices can be used if qualified by usage in similar applications and screened in accordance with a. above.

c. Commercial parts devices may be used only if it can be established that they meet the requirements of this document and have been screened in accordance with a. above. Commercial integrated circuits may be used only if subjected to a visual inspection before encapsulation and to screening.

Control of parts for in-house design shall be through close coordination between reliability specialists and designers, parts application reviews and reliability sign-off of drawings and parts lists.

Control of parts for supplier items shall be through parts selection criteria and approval, and through requirements contained in procurement specifications reviewed and approved by Reliability.

Additional parts screening may be required where deemed necessary and a screening burn-in of black box level hardware will provide additional assurance that the required reliability levels can be maintained. Where required to support reliability evaluations, a parts tabulation shall be prepared for all satellite design, new and established, listing complete part identification, derating factors, failure rates and failure rate sources.

Selection of critical materials and processes will be controlled similarly to that for parts. That is, through specific requirements in procurement specification. In-house material and process selection will be made through the established Materials and Process Standards supplemented by specialists assigned to the program.

For new parts selection, Boeing's Aerospace Experience Analysis Center will provide assistance in determining if tests on the selected parts have already been conducted by other contractors or government agencies. The Boeing Aerospace Electrical/Electronic Technology and Standards and Specifications organization will assist in determining whether these parts have been tested by Boeing for other programs. This will prevent duplication of testing when adequate test data is already available and will allow curtailment of other tests for which some of the required data already exists.

Boeing is an active member of the Government Industry Data Exchange Program (GIDEP). A complete file of all GIDEP material is available within the Center. Information from this file will be used to avoid duplication of parts testing. This parts information will also be made available to suppliers who request assistance.

Design practices are closely controlled through existing corporate, group and division design manuals and program instructions directing the use of these standards. The use of these standards will be monitored through design review and through the review and approval process applied to drawings, specifications, and test procedures.

3.3 SUPPLIER SELECTION AND CONTROLS

Reliability and maintainability requirements will be imposed on suppliers consistent with those imposed on Boeing design and appropriate to the equipment being procured. These requirements will be selectively imposed by the procurement specifications commensurate with the state of design (e.g., new, major modification, off-the-shelf), cost and criticality. Existing S3 hardware will be used extensively and will be procured to existing supplier specifications and drawings. Typical requirements include the following:

a. Reliability Analysis - The supplier will be required to conduct a reliability analysis to show compliance with the specified minimum reliability requirements. Reliability data from other programs which are flight-proven identical hardware shall be considered as adequate indication of compliance by comparison, provided that the data is submitted and/or the source information provided. As an alternate, component failure rates may be used to demonstrate the reliability figure. Existing S3 analyses will be used where applicable.

b. Failure Mode and Effect Analysis - The supplier will provide sufficient detail data to the contractor to support the FMEA. Existing S3 data will be used where applicable.

c. Failure Reporting and Corrective Action - Supplier will be required to maintain a system for reporting all failures during qualification and acceptance testing on Boeing-supplied forms (or equivalent). Failure reports will be sent to Boeing within three days after failure occurrence for prompt processing by the Design Engineering and Reliability/Safety and Configuration Control organizations.

   The supplier will be required to investigate the cause of failure and define the corrective action necessary to prevent recurrence. Materiel and Reliability/Safety and Configuration Control organizations will maintain follow-up records to ensure that proper corrective action, when required, has been taken to prevent failure recurrence. Suppliers will be required to report follow-up action on each failure not resolved.

3.3.1 SOURCE SELECTION

Reliability and maintainability at the subcontract level for the BSRM program starts with the preparation of specifications containing reliability and maintainability requirements. Existing S3 sources will be used extensively and previous supplier proposal data will be considered applicable. Prior to preparation of requests for any new proposal, the industry capability will be reviewed for capable sources and interest. Request for proposals will contain a numerical reliability requirement; the description of, and requirement for, other reliability items. Criteria for proposal evaluation established prior to receipt of proposals will be used in the proposal rating process. Proposals will be reviewed by Engineering, Materiel, Quality, and Reliability/Safety and Configuration Control organizations. During the review process, bidders may be requested to clarify or amend any questionable areas or deficiencies in their proposals.

After receipt of any bidder proposal addenda, a final rating is made and the supplier selected.

3.3.2 CONTRACT COMPLIANCE

After selection of a supplier to participate in the BSRM program, and during the negotiation period, the reliability requirements as specified in the procurement specification are reviewed with the supplier for understanding and agreement. The follow-up plan to ensure contract compliance entails four main elements:

a. The design reliability analysis required of suppliers is specified in the Source Control Drawing, and production of the end item cannot be approved until all critical design requirements are fulfilled.

b. Failure reporting by suppliers is subject to surveillance at the sources by the Boeing Quality Representative.

c. Supplier corrective action is required for hardware failures affecting reliability. The suppliers' proposed corrections require concurrence of both Boeing Engineering and Quality Control.

d. Review and approval of data presented at the design review.

3.3.3 DESIGN REVIEWS

For any new items other than qualified S3 components, the supplier will be required to submit design data and a drawing package to the contractor before the design review. Representatives of the contractor's Reliability/Safety and Design Engineering organizations review all of the supplier's data and drawings, and reliability personnel will attend the supplier's design reviews as often as determined to be necessary. In all cases, the contractor will approve supplier reliability analyses and reports and review supplier design validations before granting design approval.

3.4 SYSTEM SAFETY PLAN

The System Safety Plan defines the tasks by which the Contractor plans to meet the safety requirements of the Statement of Work. The overall objectives of the plan are to develop an effective safety program which, through analysis, establishment of requirements, design and procedures review, and monitoring of potentially hazardous operations, will identify and eliminate or control safety critical aspects of the program. The primary objective of the Safety Program is the elimination of Category IV hazards and the minimizing of Category III hazards, consistent with system objectives.

The scope of the plan encompasses all safety activity related to the BSRM satellites and Boeing designed AGE and GHE. It also includes establishment of safety interface constraints for payload potential hazards and the establishment of an integrated payload radiological safety program.

3.4.1 ORGANIZATION

System Safety interfaces with the reliability organization. Both organizations are under the Reliability/Safety and Configuration Control manager. System Safety is supported, when required, by the Aerospace Product Support Engineering (Safety) staff, and the Industrial Hygiene and Safety and Radiation Health Protection corporate staff organizations.

3.4.2 SAFETY PROGRAM TASKS

The Safety Program Tasks are identified below in sequence, and phased with the program milestones.

3.4.2.1 Program Go-Ahead.

a. Prepare Safety Program Plan.

b. Provide safety data requirements for Interface Control Drawings.

c. Release standard safety criteria including equipment safety requirements for satellites and AGE/GHE.

d. Perform Preliminary Hazards Analysis and update safety design criteria. Identify safety critical aspects and hazards.

e. Provide Safety Inputs to CI Part I Specifications.

f. Evaluate satellite design concepts.

g. Review and approve AGE/GHE engineering drawings.

3.4.2.2 Critical Design Review

a. Present Preliminary Hazards Analysis Results.

b. Review and approve engineering drawings.

c. Prepare Radiological Safety Analysis Summary (if required).

d. Review and complete Range Safety checklist, progressive with design.

e. Prepare Ground Safety Plan.

f. Provide Safety inputs to CI Part II Specifications.

g. Provide safety inputs and review and approve test plans and procedures, ground handling and transportation plan, for safety critical aspects and controls.

h. Monitor safety-critical tests, and coordinate requirements with Industrial Safety and with Radiological Safety organizations (if required).

i. Review test results and failures for potential hazards.

j. Checkout design compliance with all safety requirements for preacceptance review.

3.4.2.3 Acceptance Review

a. Confirm completion of all safety analyses.

b. Confirm compliance of deliverable hardware (AGE and flight systems) to safety requirements.

3.4.3 HAZARD LEVELS

For the purpose of providing a qualitative measure of the hazards to be identified in the Preliminary Hazards Analysis, MIL-STD-882 levels will be used defined as follows:

a. Category I - Negligible

Conditions such that personnel error, environment, design characteristics, procedural deficiencies, or subsystem or component failure or malfunction will not result in personnel injury or system damage.

b. Category II - Marginal

Conditions such that personnel error, environment, design characteristics, procedural deficiencies, or subsystem or component failure or malfunctions can be counteracted or controlled without injury to personnel or major system damage.

c. Category III - Critical

Conditions such that personnel error, environment, design characteristics, procedural deficiencies, or subsystem or component failure or malfunction will cause personnel or major system damage, or will require immediate corrective action for personnel or system survival.

d. Category IV - Catastrophic

Conditions such that personnel error, environment, design characteristics, procedural deficiencies or subsystem or component failure or malfunction will cause death or severe injury to personnel, or system loss.

Based on these definitions, Category IV hazards will be eliminated by design or procedures (excluding equipment protection from lightning, as effectiveness of grounding systems cannot be established), and Category III hazards shall be minimized consistent with program objectives.

3.4.4 DESIGN AND PROCEDURES CRITERIA

Based on the Preliminary Hazards Analysis, safety criteria shall be established, to provide a base for system design. These criteria, through their incorporation into the CI specifications, will become requirements for the design. Existing S3 designs, procedures, AGE, etc., already contained in published S3 Hazards Analysis documentation will not be reanalyzed.

System Safety shall provide the safety criteria for inclusion into the CEI Specifications, as indicated in the organizational interfaces in Section 2 (Figure 2-2); assurance that the criteria are included in the CEI specifications will be ensured by the required review and approval of the documentation (CDRL Items A004 through A009) by System Safety, prior to its release.

Compliance of the design with CEI requirements shall be monitored by System Safety through review and approval of engineering drawings, test plans and procedures.

Revisions to all of the above documentation also shall require review and approval by System Safety.

3.4.5 SAFETY ANALYSES

3.4.5.1 Preliminary Hazards Analysis. The initial safety task is a Preliminary Hazards Analysis of the satellite system, and other related Boeing designed

equipment. It shall identify all safety critical aspects of the program (systems, facilities, events, processes and operations) for the purpose of developing safety design criteria to be incorporated into the CI specifications and associated procurement specifications, design requirements and procedures. The analysis will be performed as specified by paragraph 5.8.2.1 of MIL-STD-882.

In particular, the analysis shall include a detail review of the safety requirements of AFSC Handbook DH-1-6 (Design notes 3GX, 3HX, and 3RX) and requirement No. 1 of MIL-STD-454C, for applicability to the BSRM Project. A rationale for exclusion of individual requirements shall be provided, and the applicable requirements shall be identified, together with the CI specifications into which they will be incorporated.

3.4.5.2 Post-Analysis Action. The results of the Preliminary Hazards Analysis shall be reviewed with the project design and test organizations for incorporation of criteria and requirements into the BSRM system. Any Category IV satellite hazards shall be eliminated by design changes, requiring system safety approval. Category III shall also be eliminated when possible, or minimized and controlled. Elimination and control of hazards may require design trades, which shall be evaluated for effectiveness by the System Safety organization.

3.4.5.3 Random Re-Entry From Orbit. The contractor will review satellite components for characteristics (large mass, high melting point) which could constitute a hazard during random re-entry, and where feasible will design for eliminating or decreasing the hazard. The review will include supplier and Boeing designed equipment.

3.4.6 NON-DELIVERABLE DATA

Program internal directives and correspondence required for the accomplishment of the safety tasks are not deliverable; however, safety directives will be available for review by the customer.

Hazards and accident data and safety publications originated within Boeing and/or obtained from the Government or industrial sources, or transmitted to the program by the Government, will be reviewed by Safety Engineering for applicability to the program.

3.4.7 TRAINING

No special safety training is anticipated for the BSRM program, as the hazards involved and related procedures closely match those of existing contracts, equipment procedures and industrial practices. The operating personnel handling or controlling hazardous materials at Boeing, i.e., ordnance, radioactive sources, will be required to be certified or to have equivalent experience. This requirement shall be included in all test procedures ensuring that qualified personnel perform or control all hazardous operations.

3.4.8 GROUND HANDLING, STORAGE, SERVICING AND TRANSPORTATION

The applicable requirements and guidelines of AFM 127-101 "Accident Prevention Handbook" will be applied to the BSRM project, for ground handling, storage, servicing and transportation of all program equipment. Handling and servicing equipment at Boeing complies with the requirements established by Industrial Hygiene and Safety, is calibrated and/or proof tested periodically, and complies with applicable Federal and Washington State requirements.

Handling and servicing equipment designed specially for the program will comply with standard safety design practices (Boeing Standards) and Safety design and procedures requirements of AFM-101.

3.4.9 FACILITIES AND SUPPORT REQUIREMENTS

Safety critical aspects relating to facilities will be identified during the Preliminary Hazards Analysis, and the resulting safety requirements will be incorporated into test procedures. These procedures will also contain cautionary notes to ensure facility compliance with safety requirements during tests and operations.

3.4.10 RANGE SAFETY

The applicable Range Safety Requirements of the BSRM launch site will be included in the satellite CI specifications. System Safety will ensure compliance with these requirements by the use of the Range Safety Checklist, and by review and approval of design, test and analysis data, and test and checkout procedures.

A waiver to paragraph 8.3.5 of Section C of AFWTRM 127-1 exists for the S3 program. The waiver will be included in the applicable CI specification and will be continued for the BSRM program.

3.4.11 EXPLOSIVES AND ORDNANCE SAFETY

EED's shall comply with the requirements of the BSRM launch site. The EED shall also be required to comply with Paragraph 3.2.3.1 of MIL-E-6051D, as modified to provide for a 20 db safety margin.

3.4.12 RELATIONS WITH OTHER CONTRACTORS

The specifications for procurement of equipment from suppliers will be subject to System Safety review and approval to ensure safety requirements have been included. The equipment will be identified in the Preliminary Hazards Analysis. Compliance with the safety requirements will be verified at the equipment critical design reviews.

The safety interfaces with Payload contractor/agencies will be established at Payload Interface meetings. During these meetings, the Payload contractor/agencies will be requested to provide data on payload hazardous materials/equipments, required for the Preliminary Hazards Analysis and Range Safety Documen-

tation. Radioactive materials data will also be requested for integration into the Radiological Safety Report (if applicable).

3.4.13 SAFETY TESTING

No safety testing is anticipated on the BSRM program to acquire safety data with the exception of standard production proof testing of handling slings, calibration of test instrumentation and standard ordnance production tests. Ordnance RF susceptibility testing may be required if the selected ordnance has not been previously tested.

Radiation surveys of any radioactive sources associated with the payloads shall be performed at Boeing to ensure that the sources are safe for handling, during assembly and test operations.

3.4.14 SYSTEM SURVEILLANCE

Government safety personnel at the BSRM launch site will have the responsibility for surveillance of compliance with safety procedures during the satellite ordnance arming functions prior to launch.

Boeing safety personnel shall have the responsibility for ensuring all applicable safety cautions, requirements and procedures are included in the Test Procedures.

The Boeing Industrial Hygiene and Safety Organization will have responsibility for safety surveillance during all hazardous operations at Boeing relating to BSRM manufacturing and testing.

3.4.15 RADIOACTIVE MATERIALS

On previous low cost satellite programs at Boeing certain GFE payloads included internal radioactive sources. Also, radioactive sources have been used externally to the satellite for calibration purposes. For the BSRM program, if radioactive materials are used, they will conform to the following:

a. All operations involving the use of payload radioactive materials at Boeing facilities, and during Boeing transportation of equipment to the launch site, will be conducted in compliance with all applicable Federal, State and Government regulations. This includes the control of receiving, storing, transferring and using of all sources of ionizing radiation.

b. The Radiation Health Protection Staff has the authority and responsibility to order the immediate cessation and correction of any operation found to constitute an unsafe radiation hazard, or which is not in conformance with pertinent government standards, laws and regulations.

c. For all contractor operations relating to radioactive materials, the applicable requirements of Boeing's "Industrial Hazards Control Bulletin No. 76" will apply. Included shall be:

Appendix A - Maximum Permissible Exposure Limits
Appendix B - Acceptable Radiation Work Practices
Appendix C - Emergency Procedures

d. The contractor will identify to the government established safety criteria requirements and controls to eliminate or minimize hazards generated by radioactive materials. The contractor will also compile and provide to the government a description of all radioactive sources used in the satellite systems, including approximate location, quantities, strength, manufacturer, and other known data valuable for alerting personnel working on the satellite system about the existing radiological hazards.

e. The contractor will be responsible for obtaining and maintaining applicable licenses to possess specifically licensed radioactive materials.

For the BSRM safety program, the safety engineer will have the technical support of the Radiation Health Protection Staff, which under the Boeing Corporate Director of Medical Services, has the responsibility to:

a. Develop, publish and monitor the implementation of standards for health protection from ionizing radiation hazards.

b. Provide technical leadership, advice and assistance for compliance with applicable radiation control standards and regulations in the operation of facilities or processes involving radiation sources.

The Radiation Health Protection Staff also has the responsibility for administering a radiation protection program and monitoring service for all operations in the contractor's facility, during Boeing transportation and for Satellite Safety procedures at the launch site. The program will:

a. Enforce compliance with radiation protection standards and regulations.

b. Ensure that personnel have been adequately endoctrinated for safe operation involving the use of radioactive materials.

c. Conduct surveys of Boeing test operations employing radioactive materials, and monitor any corrective action necessary to satisfy governmental requirements concerning the use of radioactive materials.

d. Provide technical counsel to the Isotope Committee relative to Atomic Energy Commission licensing requirement for acquisition and use of radioactive materials when intra-company transfers of specifically licensed radioactive materials are involved.

3.5 QUALITY CONTROL PLAN

Existing quality control plans and procedures successfully used on previous Boeing spacecraft programs will be used for the BSRM program. The objective of the quality control program is to obtain a successful test and flight by obtaining trouble-free operation of all equipment early in the program and by assuring that quality will not be degraded by human factors, procedures and testing.

The Quality Assurance organization has the responsibility of ensuring that all delivered equipment conforms to design and contract requirements. This is accomplished by a continuing surveillance of all phases of design, procurement, manufacture, and delivery. This function starts during the early phase of design to ensure that quality and acceptance criteria are evaluated for completeness and for compliance with contract requirements. Quality Assurance personnel review and approve all Manufacturing planning to ensure that proper and adequate quality and engineering specifications are included in the proper sequence. After production starts, Quality Assurance personnel constantly control in-process manufacturing by performing critical inspections and final inspections as specified by the planning. The complete manufacturing operation, including storage, material handling, shipping and control of Government Furnished Equipment, is included in this program.

3.5.1 PROCUREMENT CONTROL

Suppliers are required to demonstrate compliance with quality standards, procedures, and processes established for the contract. Purchase Orders will be screened to verify that quality, design and contractual obligations have been included. The supplier will supply records of actual test data with the corresponding shipments of materials, parts, or assemblies. This test data will be compared with Receiving Inspection results to check quality trends. Upon receiving, purchased articles will be inspected for supplier conformance to terms of the Purchase Order, as well as required physical and functional characteristics.

3.5.2 PRODUCT CONTROL

3.5.2.1 Work Plans. The fabrication, assembly and test processes are controlled through Manufacturing work plans containing the sequence of work in such detail as necessary to accomplish the job and to maintain a progressive acceptance history of work performed. The quality characteristics to be inspected or controlled are integrated with these work plans to ensure that Engineering requirements are maintained and that all processing and fabrication are accomplished under controlled conditions.

Quality Planning approves the inspection points specified on the work plan to ensure that the product is inspected at the proper stage of fabrication or assembly. Quality stamps and dates the work order indicating final acceptance of the product to the engineering drawing and the referenced process specifications.

3.5.2.2 Acceptance Criteria. Acceptance criteria will be based on requirements of Engineering drawing, process, or test documentation. Instructions will include standard Quality Conformance Inspection procedures that establish the inspection characteristics method, and requirements for inspection of all steps of manufacturing.

3.5.2.3 Process Monitoring. Procedures and processes will continually be monitored. Controls are established for critical processes and for the training and certification of personnel responsible for performing fabrication and inspection operations. Assurance for process qualification, process control, and for verification of operators certification status is provided for all critical processing.

Existing contractor material and process specifications and standards will be used in production. Specifications will be developed by Engineering and approved by Manufacturing, Materiel, and Quality Control when standards do not exist or when they are inadequate. Any change to a process specification is coördinated and approved by these same departments. These specifications are called out on the released engineering drawings and Manufacturing Engineering references the process specifications on the production shop order.

3.5.2.4 Material Control, Identification, Handling and Storage. Material, parts and assemblies are identified in accordance with engineering instructions before, during and after fabrication or assembly operations. Parts and assemblies are identified by part number and/or serial number. Records of the chemical and/or physical tests necessary to confirm material acceptability are maintained by Quality Control.

3.5.2.5 Nonconforming Material. The system established to control nonconforming material accounts for the requirements of identification, segregation, disposition of material, and corrective action as a result of deficiencies. The Quality Assurance organization will identify all rejected material by attaching an Unplanned Event - Rejection Tag. Disposition will be made by Quality Assurance if the material is incomplete because of work omissions or can be restored to conformance by routine correction of workmanship errors. A full Material Review Board, consisting of Engineering, Quality and Customer representatives will be held when, in the opinion of the Quality Assurance supervisor, the material is to be used "as is" or repaired. A copy of all unplanned events in the Boeing Integrated Record System is routed immediately to Engineering and Reliability for failure review and correction. The combined efforts of Materiel, Manufacturing, Engineering and Quality Assurance personnel will provide the action needed to preclude recurrence of defects. Corrective actions concerning suppliers will be coordinated with the Materiel organization to ensure that quality trends and production of nonconforming articles have been detected and analyzed, and that corrective action has been accomplished.

3.5.3 GOVERNMENT FURNISHED PROPERTY

When government furnished property is received, Boeing will inspect for damage in transit and completeness, and will implement existing controls procedures to preclude damage while in Boeing's possession.

3.5.4 CONFIGURATION ACCOUNTABILITY AND RECORDS

Configuration accountability is the element of the inspection system providing visibility and records for ensuring compliance with the complete technical description. The existing Integrated Records System (IRS) will be used as the single system for recording and accumulating the data required to show progressive evidence of hardware completion and acceptance from Source/Receiving to end product. After completion of the manufacturing cycle, a complete configuration review is made. This consists of reviewing all Manufacturing Records against the appropriate drawings and specifications to ensure that the "as-built" configuration is the same as the specification requirements.

The existing IRS procedures include requirements for configuration accountability during all test programs. Quality Control monitors test conduction to insure compliance with approved procedures and to prevent unauthorized deviations. All test equipment is inspected and approved for proof loading, calibration, etc., and verification is included in test records. Quality Control, through their approval of test work plans after test completion, verifies that all test success criteria were properly met. In the event of a test anomaly or failure to meet success criteria, an Unplanned Event - Rejection Tag is issued requiring Engineering disposition and customer approval.

3.5.5 MEASUREMENT STANDARDS AND TESTING EQUIPMENT

The certification and calibration of measuring equipment are defined and documented. These calibration and certification documents are on file with the local Air Force Plant Representative. All measurement and testing equipment used in the BSRM program will be traceable to the National Bureau of Standards with respect to calibration.

Test(s) are conducted with calibrated and certified (calcert) test equipment. Calibration and certification cycles are controlled by formal Boeing procedures, which also require that the date of the next calcert cycle be noted on a stamp affixed to the test equipment. Tests may not be conducted with outdated or non-dated equipment.

4.0 SYSTEM TEST PLAN

This plan describes the test program for the BSRM satellite. It provides a general description of the tests, states the test objectives and shows the sequence of testing. Test support requirements, test responsibilities and management, and documentation and other test controls are also defined.

The system test program for the BSRM was developed from extensive experience gained during similar test programs for other spacecraft systems. The test program ensures a thoroughly tested and reliable functional satellite. The test program offers the following features:

- o The satellite systems are functionally complete and checked out, including simulated payload interfacts, prior to mating flight payloads.
- o Complete subsystem tests assure proper operation under simulated flight conditions.
- o Complete integration tests with all flight payloads installed verify end-to-end operation for maximum assurance of satisfactory operation in orbit.
- o Use of existing test procedures, techniques and software assure on-schedule completion.
- o Compatibility established using experienced personnel and proven data interfaces.

4.1 TEST CATEGORIES

The various tests described in this plan are organized according to Category I and Category II testing. Category I tests are defined in this program as engineering development tests at the component and subsystem level. In addition, certain system level tests will be performed on the satellites prior to the installation and integration of the satellite payloads as shown in Table 4.1-1.

Category II tests are system level tests performed on each satellite during and after integration of the satellite payloads. These will include demonstration tests (generally operationally environmental in nature) and satellite final acceptance test. Table 4.1-1 shows the applicability of these tests.

4.1.1 CATEGORY I DEFINITION

The objective of the engineering development testing phase of the BSRM program is to obtain engineering data necessary to determine adequacy of the design and the functional parameters of the subsystems. These tests will verify that the design operates within the predicted limits when the hardware is subjected to simulated operational conditions.

The objective of system level functional integration and system performance testing without payloads is to verify the functional operation and compatibility of all satellite subsystems, and verify the payload electrical interfaces prior to their installation.

TABLE 4.1-1: CATEGORY I & II TEST MATRIX

	Spin-Stabilized		3-Axis Control	
	First Unit	Each Unit	First Unit	Each Unit
Category I:				
Struct/Mech	X		X	
Antenna Pattern	X		X	
Component Magnetic Test	X		X	
Functional (w/o Payloads)		X		X
System Perf. (w/o Payloads)		X		X
Category II:				
Qualification	N/A	N/A	N/A	N/A
TM Calibration		X		X
Functional (with Payloads)		X		X
Flight Simulation		X		X
Preliminary Mass Properties		X		X
EMC		X		X
Mag. Survey		X		X
Resonance Search		X		X
Acoustic		X		X
SPT		X		X
Shock		X		X
SPT		X		X
Thermal Vacuum	X		X	
SPT	X		X	
STDN Compatibility	X		X	
Deployment		X		X
Final Mass Properties		X		X
Acceptance		X		X

4.1.2 CATEGORY II DEFINITION

The objectives of the system level demonstration tests are to integrate the payloads with the satellite, demonstrate performance of the satellite subsystems in conjunction with the payloads, and verify that the satellite system, subsystems, and payloads meet design requirements, are compatible, and operate properly within operational environments.

The acceptance test is performed after the completion of all demonstration testing with the objectives to verify that the satellite meets performance requirements and is ready for acceptance review and delivery.

4.2 BOEING MOBILE TEST LAB (MTL)

Spacecraft testing is conducted using a Boeing-owned command and telemetry ground station to verify satellite performance. The MTL contains the equipment required to:

- o Receive and evaluate satellite telemetry data.
- o Record test data.
- o Transmit satellite commands.
- o Identify out-of-tolerance measurements.
- o Format and display selected test data.
- o Service operator requests for data processing, command generation and transmission, display formatting and software operation.
- o Retrieve, display and print selected data.

The equipment is contained in an 8 feet high by 8 feet wide by 34 feet long equipment module mounted on a four-wheel trailer. The wheels are removable for air or road mobility. The MTL is described in detail in D180-18431-2. Figure 4.2-1 presents a block diagram showing the manual and computer-controlled test modes.

The use of the Boeing MTL shortens test schedules and reduces program costs. It stores test procedure sequences, satellite commands and go/no-go limits in the computer memory and provides automatic execution and verification of pre-established test criteria. The similarity of the S3 and BSRM subsystems allows a large portion of existing test procedures and computer software to be used without modification in the BSRM program.

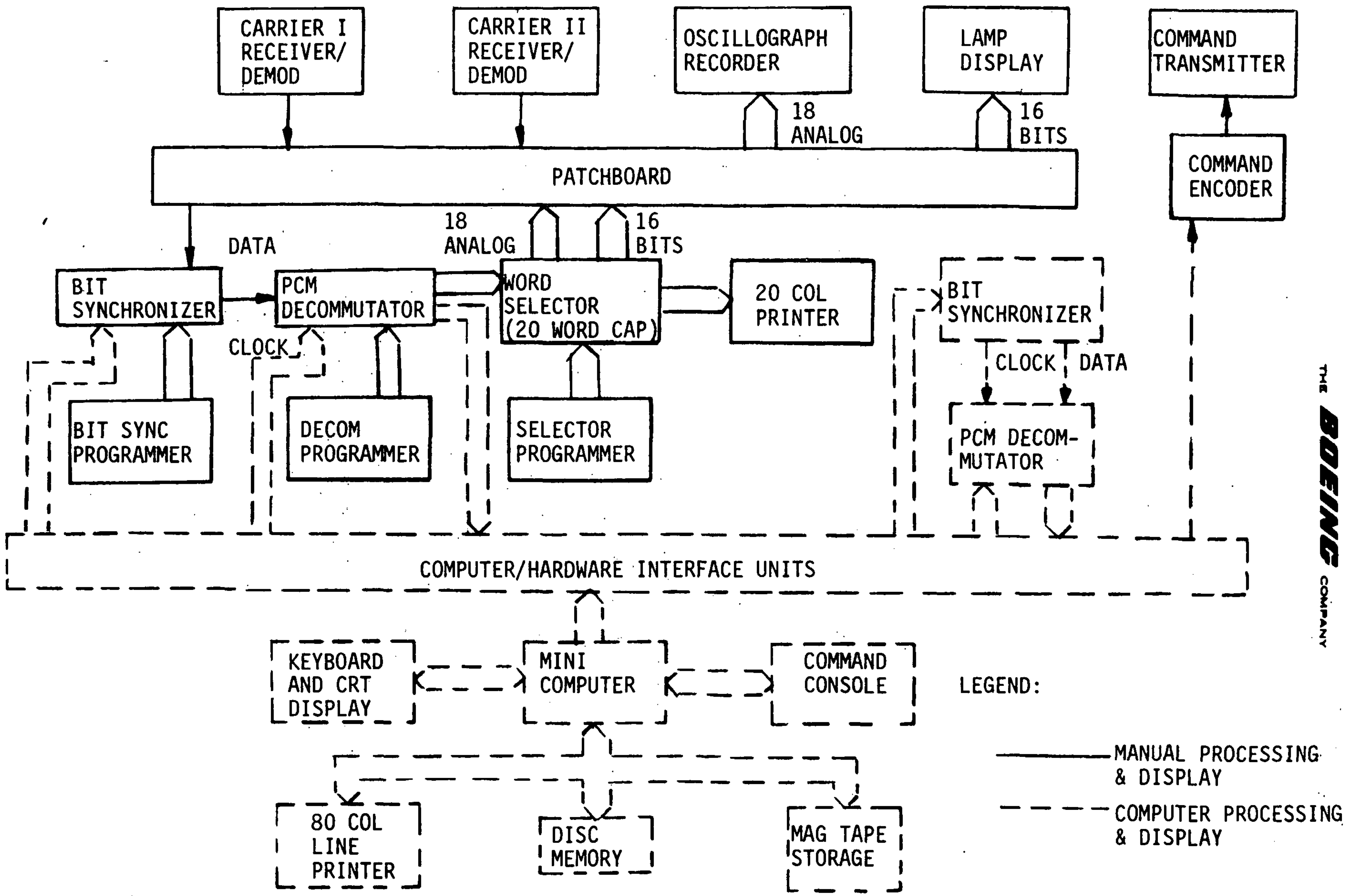

FIGURE 4.2-1: BOEING MTL BLOCK DIAGRAM

4.3 CATEGORY I TESTS

The first BSRM satellite, either spin-stabilized or 3-axis stabilized, will be subjected to the following engineering development testing, functional testing without payloads, and system performance test. Category I tests on succeeding BSRM vehicles will be only functional integration without payloads and system performance test without payloads.

4.3.1 STRUCTURAL/MECHANICAL DEVELOPMENT

Developmental tests will be performed on a structural model to verify that the design meets critical structural and mechanical requirements. The structural model will consist of the BSRM flight structural assembly, mass simulated equipment and payload components, flight quality mechanisms (including booms) and dummy solar panels.

4.3.1.1 Resonance Search.

Purpose. To determine the fundamental natural frequency of the satellite when attached to a rigid interface at the Scout clamp ring. Requirements are greater than 100 Hz in the axial direction and 20 Hz in the lateral direction. Any secondary resonances will also be determined.

Configuration. BSRM flight structural assembly with mass simulated equipment and payload components, flight quality mechanisms and dummy solar panels.

Test Description. The satellite will be mounted on a shaker table and subjected to a low level sine vibration sweep test from 10 Hz to 200 Hz in each axis. Sweep rate will be one octave per minute, and input will be controlled to limit the maximum response at major resonances to 2.0 g's. Accelerometers will be installed at selected locations to measure responses and identify resonances.

4.3.1.2 Acoustic Vibration.

Purpose. To determine vibration response at 3 dB above expected boost acoustic environment.

Configuration. BSRM flight structural assembly with mass simulated equipment and payload components, flight quality mechanisms and dummy solar panels.

Test Description. The satellite, supported by an acoustic test fixture, will be installed in a reverberant test chamber and subjected to the maximum expected boost acoustic environment for three minutes. Test tolerance will be +3 dB and -6 dB from 50 to 200 Hz, ± 3 dB from 200 Hz to 2000 Hz, and ± 6 dB from 2000 Hz to 10,000 Hz on 1/3 octave bands. Tolerance on overall level will be ± 1 dB. Accelerometers will be installed on selected equipment component and payload simulators to record vibration response. Power Spectral Density analysis of the recorded responses will be performed.

4.3.1.3 Separation/Deployment Shock Test.

Purpose. To determine the payload and equipment component responses to pyrotechnic shock events.

Configuration. BSRM flight structural assembly with mass simulated equipment and payload components, flight quality mechanisms and dummy solar panels.

Test Description. The satellite will be installed on a test fixture and all ordnance will be fired one time for the following events:

a. Satellite separation from Scout (V-band)

b. Yo-Yo despin (Pin pullers)

c. Solar array deployment (Pin pullers)

d. Antenna/magnetometer boom deployment (Pin pullers)

Accelerometers will be installed at selected locations and data recorded to determine pyro shock environment at the Scout, component, and payload interfaces. Shock responses will be evaluated to verify interface requirements are met.

4.3.1.4 Satellite Ejection.

Purpose. To verify that the V-band clamp will be successfully retained after firing and will not interfere with satellite ejection.

Configuration. BSRM flight structural assembly with mass simulated equipment and payload components, flight quality mechanisms and dummy solar panels.

Test Description. This test will be performed in conjunction with the V-band clamp pyro shock test. The satellite will be mounted vertically, counterbalanced and the V-band clamp separation ordnance initiated. Separation of the satellite and the V-band clamp will be recorded by high speed motion picture cameras to verify clamp retention and non-interference.

4.3.1.5 Solar Array Deployment

Purpose. To determine deployment force margin and deployment time and demonstrate a minimum first mode frequency of 2.0 Hz in the deployed position.

Configuration. BSRM flight structural assembly with flight quality mechanisms and dummy solar panels. Mass simulated equipment and payload components are optional. Flight equivalent wire bundles will be installed across all movable joints to simulate their effect on deployment characteristics.

Test Description. Dummy solar panels will be installed on the satellite. The satellite will then be installed in the deployment separation test fixture with the panels supported by a spring-cable counterbalance system to simulate zero-g condition. The panels will be mechanically released. Functional operation, deployment springs and stops will be verified. The test will be performed a minimum of five times to verify operation and repeatability.

4.3.1.6 Boom Deployment.

Purpose. To determine deployment force margin and deployment time. Minimum

first mode frequency of 2.0 Hz will be demonstrated in the deployed position and alignment repeatability will be verified.

Configuration. BSRM flight structural assembly with flight quality mechanisms. Mass simulated equipment and payload components and dummy solar panels are optional. Flight equivalent wire bundles will be installed across all movable joints to simulate their effect on deployment characteristics.

Test Description. Flight equivalent booms and actual or mass simulated antennas will be installed on the satellite. Any other equipment items installed on the booms will be mass simulated. The satellite will be installed in the deployment system to simulate zero-g conditions. The antenna release mechanisms will be mechanically initiated. Functional operations of the booms, deployment springs, and stops will be verified. Deployment spring margins, antenna and magnetometer alignment repeatability, and boom frequency will be measured. The deployment test will be repeated a minimum of five times to verify operation and alignment.

4.3.2 ANTENNA PATTERN TESTS

Purpose. To determine the exact location, orientation and configuration of the satellite antenna to satisfy the RF link performance and spatial coverage requirements.

Configuration. The antenna will be mounted on a model simulating the significant satellite features. The test antenna will be a prototype model of the flight hardware.

Test Description. The pattern tests will be conducted at the Boeing Company Antenna Range. The antenna will be positioned on the spacecraft model and rotated around two orthogonal axes to provide complete spatial coverage data. Radiation patterns will be measured at right hand circular polarization at the command and telemetry frequencies for each antenna location. Antenna directive gain levels referred to an isotrope will be obtained from the recorded radiation patterns by computer processing.

4.3.3 COMPONENT MAGNETIC TESTS

Purpose. To determine hard perm and soft perm of satellite components and subassemblies and assess possible levels of interference with operation of payloads and the satellite attitude control system. This test will be applied to items for which this information is otherwise unavailable and which contain significant magnetic materials.

Configuration. Tests will be performed in the Magnetic Research Laboratory at the Boeing Kent Facility. The test item will be mounted on a nonmagnetic turntable and rotated. A fluxgate magnetometer, mounted a known distance from the table will be oriented to measure radial magnetic flux density.

Test Description. Magnetic dipole moment will be calculated from peak-to-peak flux density measurements and magnetometer spacing. Moments will be determined along three orthogonal axes of the component. Components and assemblies will not be individually compensated unless computation shows an interference flux density limit will be exceeded (see Paragraph 4.4.2.6 for satellite System Magnetic Survey).

4.3.4 FUNCTIONAL INTEGRATION WITHOUT PAYLOADS (SPIN STABILIZED)

Purpose. To make an orderly buildup of satellite equipment connection and verify proper subsystem operation before installing payloads. Figure 4.3-1 shows the functional integration test flow.

Configuration. The satellite will have all components installed and aligned except sun sensor, solar panels, ordnance and payloads. A sun sensor simulator, test battery and payload simulators will be installed. Components and payload simulators will not be connected to the satellite wiring harness at the start of integration tests.

Test Description. The satellite subsystem components will be sequentially connected to the wiring harness and functionally verified in the order presented below:

Power Subsystem

Prior to installation of power subsystem components, continuity, insulation resistance and Hi-Pot of the satellite wiring harness will have been verified per the engineering drawings during the manufacturing process.

The power subsystem consists of solar panels, blocking diodes, voltage limiter, shunt load resistors, battery, Ampere-Hour Meter (AHM), enabling switches and associated relays in the relay box. All components except the solar panels, battery and relay box will be connected together using the satellite wire harness. A current limited 28 VDC power supply will be connected in place of the battery and a power and distribution test performed. Using break-in boxes at each power subsystem interface connector, the presence of 28 VDC on the proper interface connector pin, and at no others, will be verified.

The remaining power subsystem functional integration tests will be performed during command subsystem functional integration testing as follows: After the ability to command the satellite has been established, the voltage limiter levels and AHM 0% and 100% state-of-charge and load disconnect enable and disable command functions will be verified. For each command, a solar array simulator power supply will be used to adjust the satellite array bus voltage above the commanded limiting level and the limit switching verified by presence or absence of current into the shunt resistors which is monitored by hardline through the satellite test connector. The AHM 100% state of charge enable and disable commands will be verified in a similar manner. The battery simulator power supply will then be replaced with a flight equivalent test battery which will be used during selected Category II tests performed prior to the satellite acceptance test. The ability of the power subsystem to operate properly under simulated solar power and battery power, including load sharing, battery charging and bus regulation, will be verified.

Functional integration of the solar array will be performed when the flight solar array panels are installed prior to the thermal vacuum test. The ability of each solar panel to provide voltage to the solar array bus will be verified by individually illuminating the solar panels with a photo flood light and verifying there is voltage on the solar array bus. The ability of the solar array to completely power the satellite including battery charging and load sharing under simulated orbital conditions will be verified during the thermal vacuum test.

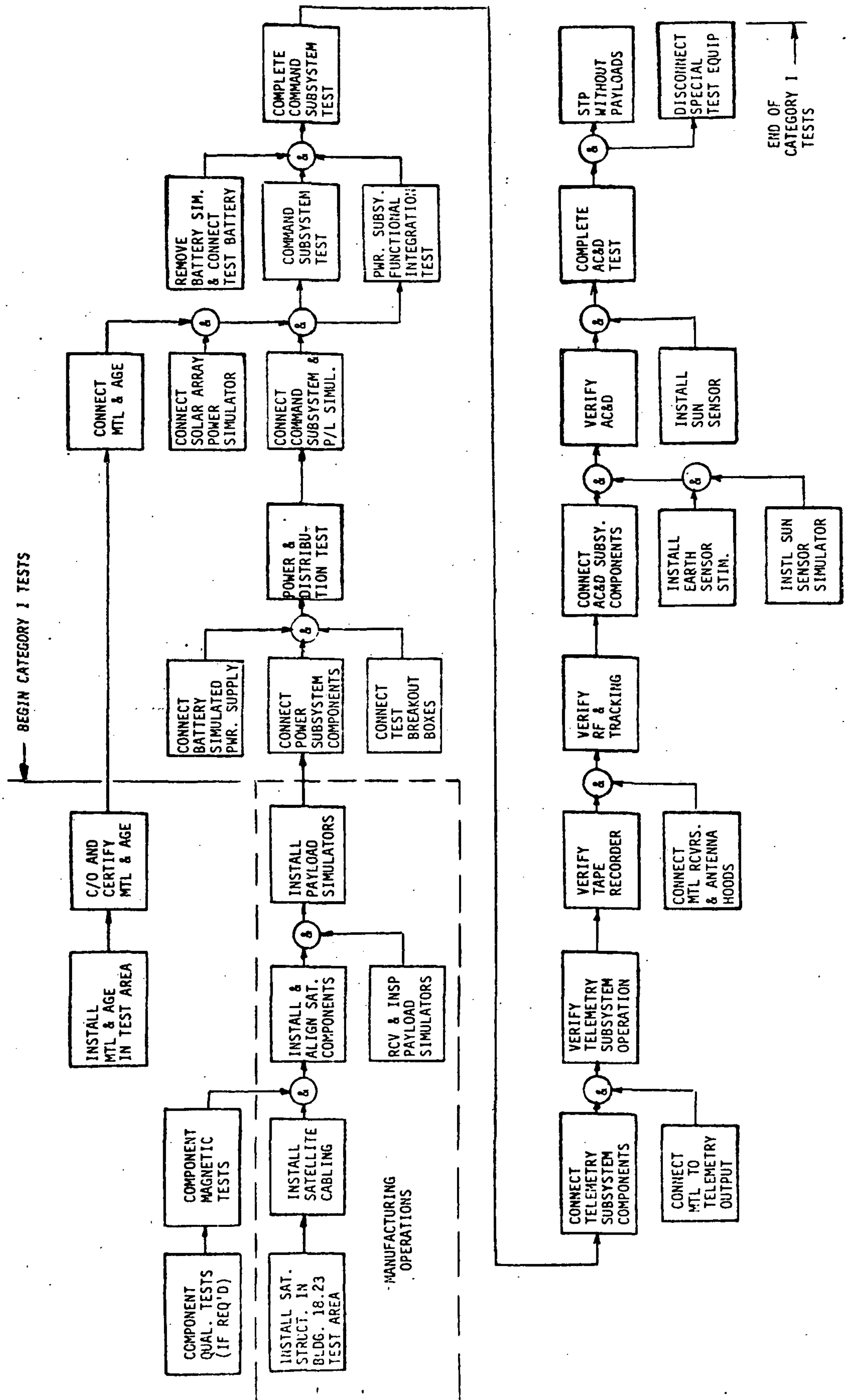

FIGURE 4.3-1: FUNCTIONAL FLOW DIAGRAM - CATEGORY I, FUNCTIONAL INTEGRATION WITHOUT PAYLOADS

Command Subsystem

Functional integration of the command subsystem will verify the ability of the satellite to receive, decode and respond properly to every satellite command. To perform this verification, all of the command subsystem components, which include the command receiver, decoder and timer, will be connected to the satellite wiring harness. The relay box which interfaces with all subsystems and payloads will be connected to provide commanded power switching to interface connectors. Break-in boxes will be connected where the command subsystem interfaces with other subsystems. Payload simulators will be connected to payload interface connectors. All satellite and payload commands will be transmitted from the Mobile Test Lab (MTL) and responses verified by instruments connected to break-in boxes and lights on the payload simulators except for the power subsystem commands described under Power Subsystem integration above. In addition, the voltage at the satellite/payload interface connectors will be verified to be within payload Interface Control Document specifications when the satellite bus voltage is adjusted to its low limit.

Telemetry Subsystem

The processor/baseband unit and tape recorder will be connected to the satellite wiring harness and the MTL connected to the telemetry output of the processor/baseband unit.

All telemetry subsystem command functions except payload will be verified by transmitting commands to the satellite from the MTL and verifying telemetry subsystem response at the MTL. In addition, the operation of the processor/baseband unit clock and gating output timing and waveforms will be verified at the payload simulators, and the recorder record, playback, fast forward, track switching and beginning and end of tape functions will be verified by telemetry at the MTL. Proper recording and playback of satellite status data will be verified during the recorder testing.

Analog and discrete payload telemetry channels will be stimulated individually at the payload simulators and monitored through a hardline connection to the MTL for verification of correct channel assignment. Satellite temperature sensors will be given a one-point calibration at ambient temperature.

RF and Tracking Subsystem

The satellite transmitter will be connected to the processor/baseband unit and satellite antennas. The MTL receiver will be connected to an antenna hood placed over a satellite antenna. Tests will be performed to verify proper RF and tracking subsystem performance. Both antennas will be tested for the spin-stabilized BSRM configuration. The tone ranging turn-around delay in the transponder loop will be determined for each vehicle.

Attitude Control and Determination (AC&D) Subsystem

The AC&D subsystem for spin-stabilized BSRM consists of spin and precession coils, earth sensor, sun sensor, magnetometer, wobble damper and relays in the relay box. These components will be connected to the satellite wiring harness,

except the wobble damper, which has no electrical connection, and the relay box which is already connected. A sun sensor simulator will be connected in place of the flight sun sensor.

AC&D subsystem operational modes will be commanded from the MTL and the resultant control action monitored as magnetic field intensity variation at the magnetic torquing coils. A compass will provide an indication of polarity changes. Telemetry and an ammeter will be used to measure current into torquing coils to indicate field strength. Spin maintenance and control will be verified by stimulating the magnetometer with a simulated rotating magnetic field and commanding a spin rate change through the command system. Correct commutation magnitude and sense will be verified by a compass. An earth sensor stimulator will supply time varying infrared stimulation to the horizon sensors to simulate earth crossings at the satellite spin rate. Correct outputs from the horizon sensors will be verified through the satellite telemetry system. The sun sensor simulator will provide simulated sun presence signals. The flight sun sensor will then be installed. Proper time tagging of the sun presence signal will be verified and proper sun aspect angle indications will be verified via telemetry at the MTL as a lamp is moved in the sun sensor field of view.

4.3.5 SYSTEM PERFORMANCE TEST (WITHOUT PAYLOADS)

Purpose. This test will be the first time the MTL will be used to perform automatic test sequences with the satellite. Its purpose will be to:

a. Verify MTL operational procedures, test sequences and software for performing automatic tests to be used during the Category II test program.

b. Verify the operational status of the satellite before integrating the payloads with the satellite.

Configuration. The satellite will have all satellite components installed except ordnance, solar panels, and thermal insulation. Simulators will be installed for all payloads. A test battery will be installed for the test.

Test Description. The MTL computers will be initialized using modified system performance test (SPT) initializing magnetic tapes. Automatic test sequences will be initiated from the MTL by transmitting commands to the satellite. Satellite telemetry response to commands will be verified for satellite functions (payloads not installed) and automatically compared against programmed go/no-go limits by MTL software. Interrupts for manual operations at the satellite, such as verification of squib simulator circuit breaker operation of payload simulator command indicator light status, will be included.

All command sequences to be used in Category II SPT's will be transmitted and those responses which can be verified without payloads installed will be verified. The satellite timer will be run in real time and stepped through its output events to verify automatic timer control.

4.3.6 FUNCTIONAL INTEGRATION WITHOUT PAYLOADS (3-AXIS STABILIZED)

The orderly buildup of satellite equipment connection and subsystem verification for 3-axis controlled BSRM will be identical to that described in paragraph 4.3.4 for spin-stabilized vehicles except for the AC&D subsystem tests discussed below. The functional flow diagram of Figure 4.3-1 is valid for 3-axis controlled BSRM spacecraft.

Attitude Control and Determination (AC&D) Subsystem

The AC&D subsystem for 3-axis BSRM consists for spin and precession coils, inertia wheel, sun sensor, magnetometer, wobble damper and relays in the relay box. These components will be connected to the satellite wiring harness, except the wobble damper, which has no electrical connection, and the relay box which is already connected. A sun sensor simulator will be connected in place of the flight sun sensor.

AC&D subsystem operational modes will be commanded from the MTL and the resultant control action monitored as magnetic field intensity variation at the magnetic torquing coils and/or inertia wheel speed response. A compass will provide an indication of polarity changes in the magnetic coils. Telemetry and an ammeter will be used to measure current into torquing coils to indicate field strength.

Magnetic torquing control will be verified by stimulating the magnetometer with a simulated magnetic field and commanding a maneuver through the command system. Correct commutation magnitude and sense will be verified by a compass. An earth sensor stimulator will supply infrared stimulation to the inertia wheel sensor to simulate earth crossing.

Correct outputs from the earth sensor will be verified through the satellite telemetry system. The sun sensor simulator will provide simulated sun presence signals for overall checkout of the AC&D subsystem. The flight sun sensor will then be installed. Proper time tagging of the sun presence signal will be verified and proper sun aspect angle indications will be verified via telemetry at the MTL as a lamp is moved in the sun sensor field of view.

4.4 CATEGORY II TESTS

Figures 4.4-1 through 4.4-3 show the functional flow for BSRM Category II tests. Each BSRM satellite will be subjected to these tests except for thermal-vacuum which will be only run on the first BSRM.

There will not be a specific test for physical integration since physical interfaces will be verified as integral parts of other tests. The interface verification between the satellite and slings and dollies will be verified at the time of their first use.

4.4.1 Qualification Tests. All components used in the BSRM will be qualified to environmental levels greater than the most severe anticipated operational environment. The methods used to demonstrate and verify design margins above those levels will vary between components but will include one or more of the following:

- o Flight Proven
- o Previously Qualified
- o Similarity
- o Analysis

The extensive use of the existing S3 subsystems eliminates the requirement for component qualification testing. Boeing will prepare a summary of data providing verification that all satellite components have been qualified to the required environmental levels. This document will be updated as component vendor data is received and analyses required to support the qualification history and designs of equipment are completed.

4.4.2 Demonstration Tests (Spin Stabilized).

4.4.2.1 Telemetry Calibration.

Purpose. To produce end-to-end calibration curves for each telemetry channel and determine the amplitude of the ambient noise.

Configuration. The satellite will have all equipment installed except payloads, satellite ordnance, rocket motors, and thermal insulation. A test battery will be installed.

Test Description. Calibration voltages will be injected into the satellite at the interface connectors where analog signals originate. The telemetry calibration will consist of three tests:

a. Three point voltage calibration test. The three point calibration test will be applied to the processor/baseband unit analog channel inputs except for channels requiring the linearity test described in "b" below. The voltages will be sequentially injected for each channel and the corresponding octal value decommutated, displayed and recorded in the MTL.

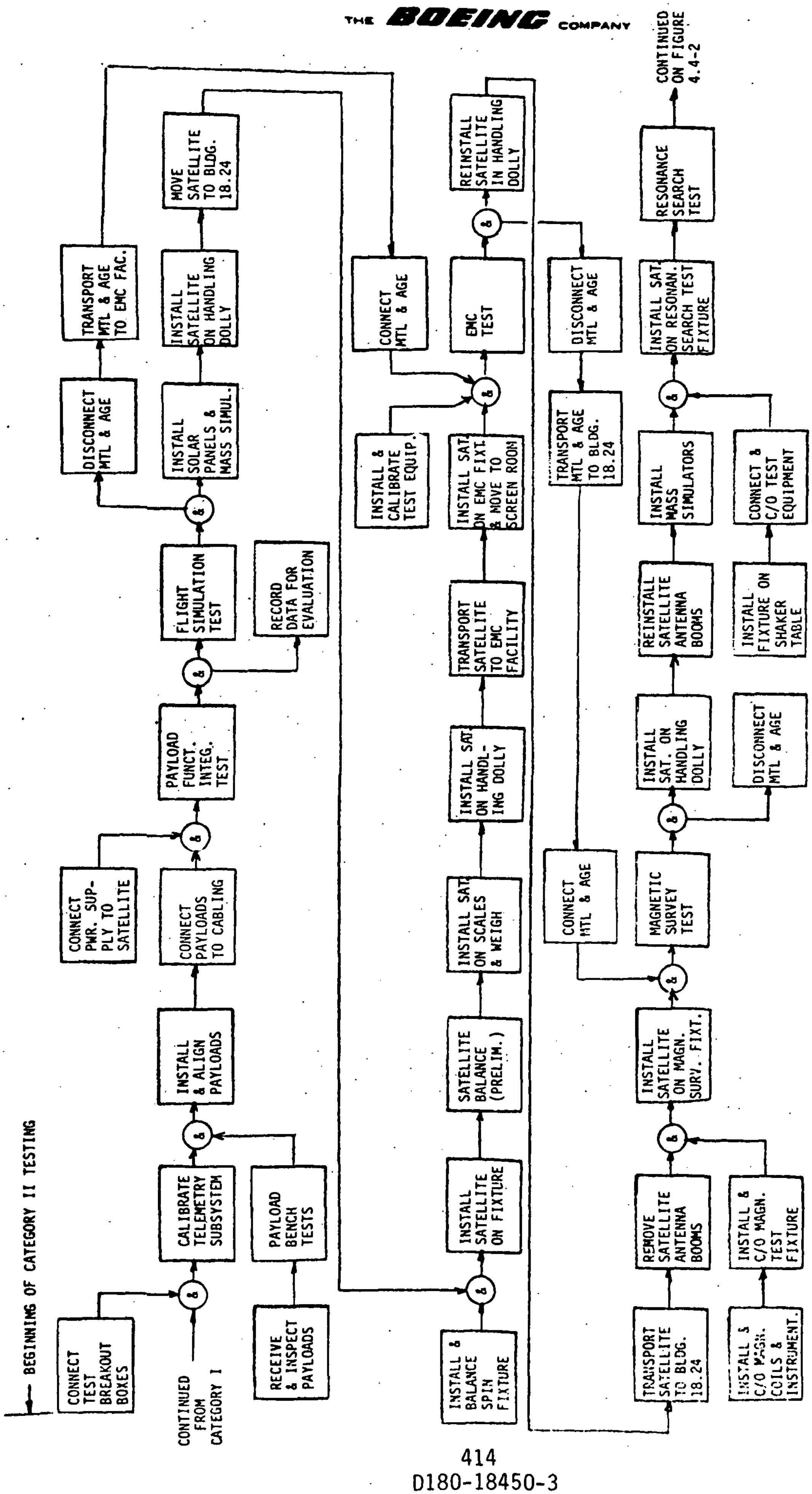

FIGURE 4.4-1: FUNCTIONAL FLOW DIAGRAM - CATEGORY II TESTING

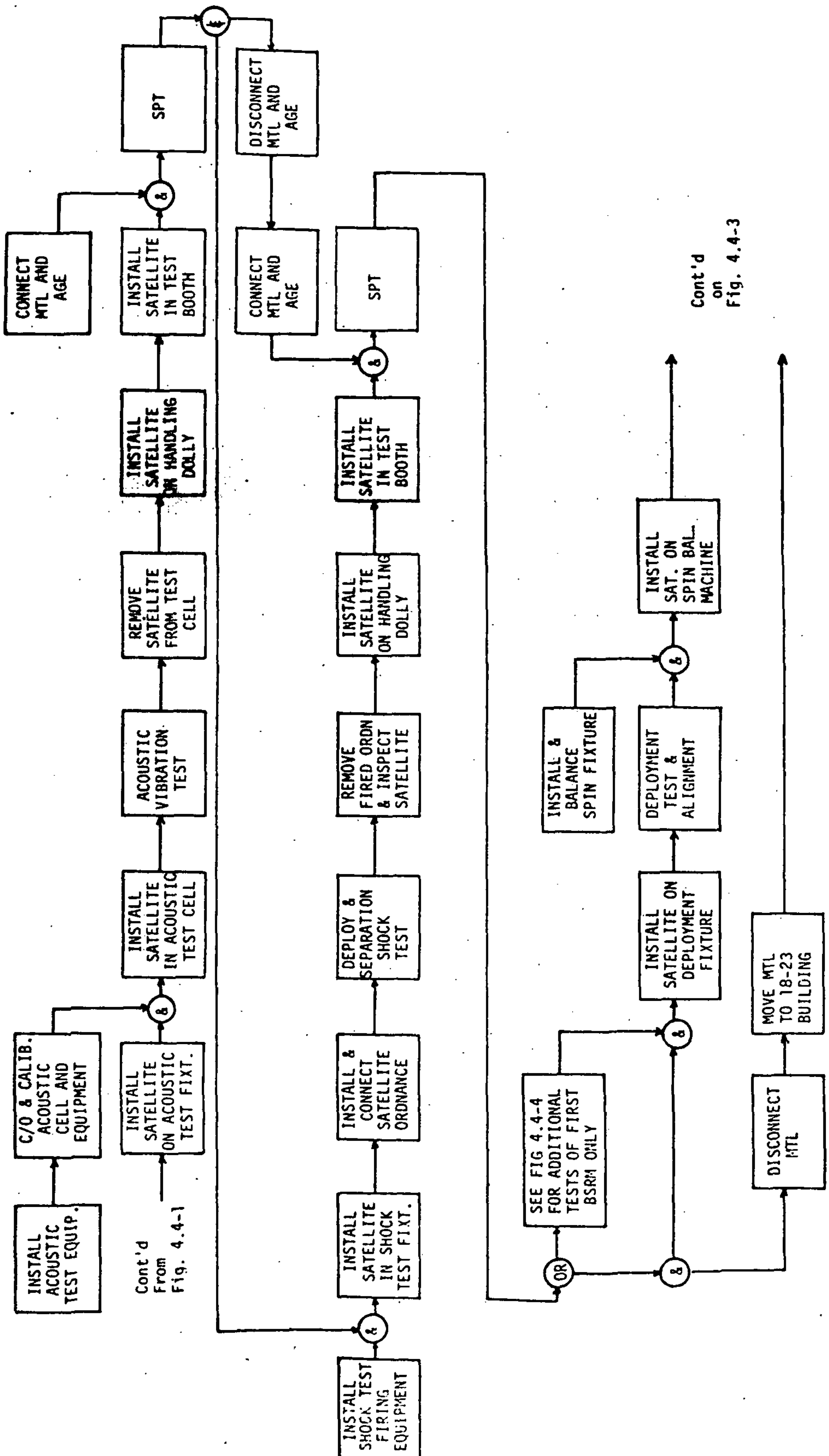

FIGURE 4.4-2: FUNCTIONAL FLOW DIAGRAM - CATEGORY II TESTING (CONT'D)

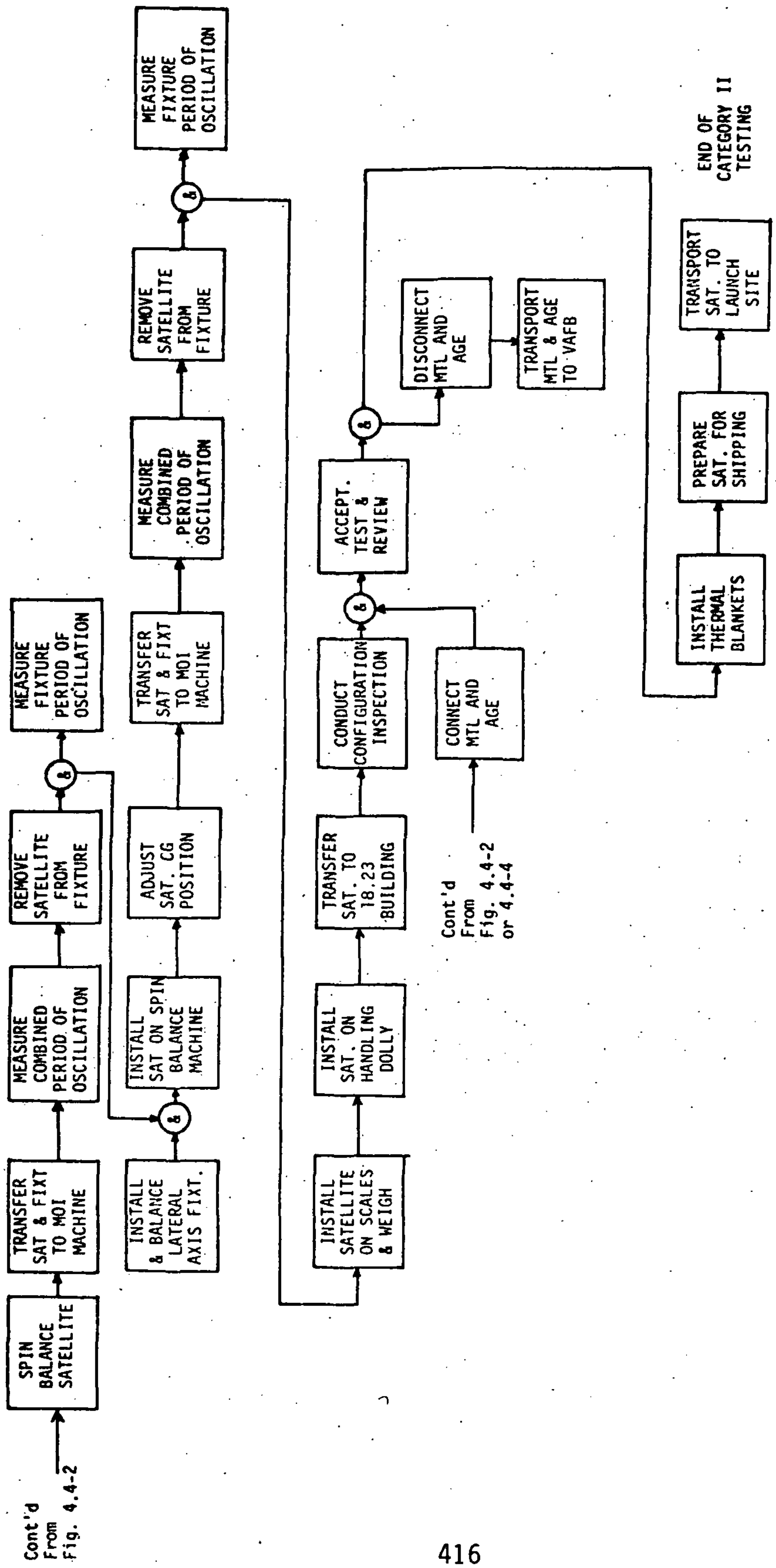

FIGURE 4.4-3: FUNCTIONAL FLOW DIAGRAM-CATEGORY II TESTING (Cont'd)

b. Linearity Test. Two representative channels will be tested for linearity verification of the processor A to D converter with a ten point calibration.

c. Analog Processing Error. A test to verify that the errors are within limits will be performed on two low level and two high level channels by injecting signals in small discrete steps from below a quantization level to above the next higher level (spanning three levels). The test will be performed using both increasing and decreasing steps. The test will provide data to enable a distribution curve of voltage input versus telemetry output to be plotted. Verification of maximum analog processing error will be made from visual inspection of the curve.

4.4.2.2 Functional Integration of Payloads.

Purpose. To verify the satellite/payload interfaces, and verify proper operation.

Configuration. The satellite will have all equipment installed except satellite ordnance, rocket motors and thermal insulation. A power supply will be used in place of the battery.

Test Description. Payload sensors will be installed and aligned by leveling the satellite using a transit or theodolites. Optical mirrors will be temporarily attached to reference surfaces on sensors requiring precise alignment. Theodolites will then be used to check the sensor alignments with respect to the satellite reference axes. Precision levels will be used where possible for sensors with large alignment tolerances. Laminated shims will be bonded to sensor mounting surfaces when required to adjust sensor mounting planes that are out of tolerance.

The functional integration of the payloads will be accomplished one at a time after all sensors have been aligned, as follows:

a. Payload Bench Test. Each payload will be bench tested by the payload contractor after arrival at Boeing to ensure proper operation.

b. Payload Connection and Test. The payloads will be connected directly to the satellite wiring harness. Each payload operational command will be transmitted from the MTL, and proper payload response will be verified at the MTL through the satellite telemetry subsystem. Payloads will be stimulated as required by payload contractors. Strip chart recordings and line printer outputs of payload data will be produced at the MTL for payload contractor evaluation. Current to each payload will be measured at the main power bus as each payload is commanded ON at high, low and nominal voltages on the main power bus.

4.4.2.3 Flight Simulation

Purpose. To verify that the total satellite system will operate within specified limits throughout a simulated flight sequence and to verify there is no interference between payloads during normal orbital operations.

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Configuration. The satellite will have all equipment installed except the solar panels, satellite ordnance, and thermal insulation. A test battery will be installed for the test.

Test Description. The Flight Simulation Test will be a computer controlled test and will include satellite simulation of initialization functions and simulation of selected orbital sequences. One orbital sequence will be performed with the timer running in real time. All other orbits will be performed by stepping the timer. The initialization simulation will start at separation and will verify occurrence of spin motor ignition signals and antenna boom deployment firing signals using squib simulators. The orbital simulation will include the following:

a. Monitoring subsystem and payload status against pre-established limits and providing an "alarm" when limits are exceeded.

b. Transmitting sequences of satellite subsystem commands and verifying responses.

c. Transmitting payload cover release commands and verifying simulated squib firings.

d. Commanding payload orbital operation sequencing and recording of payload data on satellite tape recorder. Payloads will be stimulated as required by payload contractors. During these orbital sequences, the solar simulator power supply will be controlled to generate both high and low battery voltage conditions.

e. Simulating ground station contact during real time payload operation and during satellite tape recorder dump.

f. Recording satellite data stream on magnetic tape at the MTL during simulated ground station contact. Tapes will be supplied to Goddard Space Flight Center for training and software checkout.

4.4.2.4 Preliminary Mass Properties Test.

Purpose. To verify analytical predictions and to insure that the satellite will meet weight and balance requirements at the time of the final mass properties test without repositioning subsystem or payload components. Success of the preliminary mass properties test validates the configuration for subsequent system level testing. Test results will be used to verify:

a. Satellite weight

b. Center of Gravity (Static Balance) in the injection configuration

c. Spin axis alignment (dynamic unbalance) in the injection configuration

Configuration. The satellite will have all payloads and flight components installed except spin motors. Spin motor mass simulators will be installed. All deployable devices will be in their stowed positions.

Test Description.

Balance. The spin fixture will be positioned on the spin balance machine, balanced and aligned. The satellite will then be installed on spin fixture and the static and dynamic unbalance determined around the Scout booster mounting plane. Ballast will then be adjusted as required to obtain a static and dynamic balance using ballast locations available on the satellite structure.

Weight. The satellite will be placed on scales and the weight determined. The weight will be entered in the satellite weight and balance log book. Miscellaneous loose parts that are not installed will be weighed and also entered in the log.

4.4.2.5 Electromagnetic Compatibility

Purpose. To verify the electromagnetic compatibility (EMC) of the satellite electrical equipment by demonstrating the existence of a 6 dB safety margin (20 dB for electro-explosive devices).

Configuration. The EMC tests will be conducted with all equipment installed except the thermal blankets and satellite ordnance. A test battery will be used. Thermal blankets will be used during EMC tests when antennas are radiating. Breakout boxes will be installed as required for access to critical monitor points.

Test Description. Compatibility will be demonstrated during all modes of operation while satellite subsystem and payloads are individually or collectively operated under normal flight conditions. The EMC test will use two general approaches as follows:

a. Augmentation: Satellite subsystems and payloads will be monitored for evidence of degradation in performance or improper operation, while equipments are operating through normal flight sequences and subjected to 6 dB augmented RF power density.

b. Comparison: System EMI levels will be measured and those levels compared with the MIL-STD-461A susceptibility test levels or thresholds. The difference between susceptibility and measured levels is the safety margin.

EMI measurements will be made with interference analyzers and transient voltmeters. A Fairchild FSS250 interference analyzer will be used for steady-state conducted and radiated measurements. A multichannel transient voltmeter will be employed for detection and measurement of electrical transients.

4.4.2.6 Magnetic Survey.

Purpose. The purposes of the satellite system magnetic survey are as follows:

a. Compensate the hard perm magnetic dipole moments of the satellite along each orthogonal axis.

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b. Determine expected worst case soft perm and stray magnetic dipole moments along the spin axis.

c. Calibrate the attitude control and determination (AC&D) subsystem magnetic torquing system and the satellite magnetometer.

d. Determine compliance with magnetic flux density limits for each experiment as specified in the payload interface control documents.

Configuration. The satellite will have all equipment installed except satellite ordnance, antenna booms and thermal insulation. A test battery will be installed.

Test Description. The satellite will be placed in a nonmagnetic-holding fixture which will permit placing it on a magnetic torque table with the x, y, and z axes in line with an externally produced magnetic field. The magnetic field will be produced by Helmholz coils wound on a wood frame with dimensions at least twice the satellite dimensions. The magnetic torque table supporting the satellite will allow rotation of the table top and satellite in a horizontal plane against torsional restraint springs. The magnetic component in each axis will be measured by determining the oscillations produced as the coil fields are reversed. This reversal will also eliminate effects produced by ambient unidirectional fields in the test facility. A magnetic survey will be conducted on the nonoperating satellite and magnetic moments will be compensated if required. The satellite magnetic torquing fields will then be calibrated with the satellite operating and magnetic moments will be measured. The magnetic field within the field-of-view of experiments will be surveyed to determine compatibility with requirements. For the small flux densities of boom-mounted experiments, satellite field contribution will be measured by physical displacement of the satellite.

4.4.2.7 Resonance Search.

Purpose. To verify that the fundamental natural frequency of each flight satellite when attached to a rigid interface is greater than 100 Hz in the axial direction and 20 Hz in the lateral direction.

Configuration. The satellite will have all equipment installed except ordnance. Spin motors will be mass simulated. Thermal blanket installation will be optional.

Test Description. The satellite will be mounted on a shaker table and subjected to a low level sine vibration sweep test from 10 Hz to 200 Hz in each axis. Sweep rate will be one octave per minute, and input will be controlled to limit the maximum response at major resonances to 2.0 g's. Accelerometers will be installed at selected locations to measure responses and identify resonances.

4.4.2.8 Acoustic Vibration.

Purpose. To verify that all satellite subsystems and payloads function properly after each satellite has been subjected to 3 dB above maximum expected boost acoustic environment.

Configuration. The configuration will be the same as for Resonance Search.

Test Description. The satellite, supported by an acoustic test fixture, will be installed in a reverberant test chamber and subjected to the maximum expected boost acoustic environment for 1 minute. Microphone data will be obtained to verify test input levels. A visual inspection and system performance test will then be accomplished to verify no system degradation.

4.4.2.9 System Performance Test (SPT).

Purpose. To provide verification that the satellite has successfully completed an environmental demonstration test without degradation to satellite components and subsystems.

Configuration. Several SPT's will be performed during the test program. The configuration of the satellite during each SPT will be the same as for the test immediately preceeding it. The configuration will be recorded in test documentation each time the SPT is performed.

Test Description. The SPT will use the same test sequence as the flight simulation test described in paragraph 4.3 except the timer will be stepped through all its output functions to conserve test time. The satellite will remain at each timer step only long enough to verify occurrence of the timed function and to transmit and verify proper response to selected command sequences. Telemetry response will be automatically verified by the MTL software programs with automatic interrupts for manual verification or out-of-tolerance telemetry data.

4.4.2.10 Separation/Deployment Shock Test.

Purpose. To verify that no functional degradation of payloads and equipment result from exposure to the pyrotechnic shock events.

Configuration. The test configuration will consist of the satellite with flight payloads and equipment components installed. Mass simulated spin motors and thermal blanket installation will be optional.

Test Description. The satellite will be installed on a test fixture and the following separation/deployment ordnance will be fired one time:

a. Yo-yo despin (pin pullers)

b. Satellite ejection (V-band clamp)

c. Solar array deployment (pin pullers)

d. Antenna boom deployment (pin pullers)

A satellite System Performance Test will then be run to verify no system degradation.

4.4.2.11 Solar Thermal Vacuum Test (First Satellite Only). Figure 4.4-4 shows the solar thermal vacuum test functional flow.

Purpose. A solar thermal vacuum test will be performed on the first spin stabilized and 3-axis stabilized BSRM satellites to verify thermal control subsystem design and to provide mathematical model data for flight temperature predictions for all BSRM satellites.

Configuration. BSRM flight satellite, complete with flight payloads except the following flight hardware will not be installed.

a. Spin and despin motors

b. Magnetometer boom

c. Satellite antenna booms

d. Satellite squibs

Test Description. The satellite will be instrumented with temperature transducers and installed on a test fixture in the thermal vacuum chamber. Instrumentation, control and data lines will be connected to the test fixture slip rings and routed through the chamber walls and to the AGE, MTL and data processing facilities. The computer/instrumentation interface will then be calibrated and an SPT will be performed to verify satellite operation in the chamber with command, control and monitor through chamber cabling and test fixture slip rings. The chamber will be pumped down and the satellite tested in a simulated earth-orbital environment. Pressure will be 10^{-5} torr or less. Solar heating, earth albedo, earth emission, and a space-sink temperature will be simulated to reproduce, as nearly as possible, the orbital radiation environment. Periods of solar occultation will be simulated by turning off the solar beam. The satellite will be tested in each of the following orbital environments:

a. Noon-midnight orbit

b. Terminator orbit

The satellite will be operated for 10 orbits in the sequence of events in each of the two orbital environments. During the sequence, the payloads will be operated for one full orbit.

Satellite commands and telemetry data receiving and processing will be provided by the MTL with additional satellite control and monitor functions provided by electrical AGE connected through the test fixture slip rings and satellite test connector.

Temperature-transducers mounted on payloads and subsystem components will be monitored and recorded during the entire test sequence including pumpdown and repressurization.

A computerized model of the thermal vacuum test will be developed and used in detailed test planning and design. The model will also provide pretest temperature predictions. These predictions will be compared with test measurements,

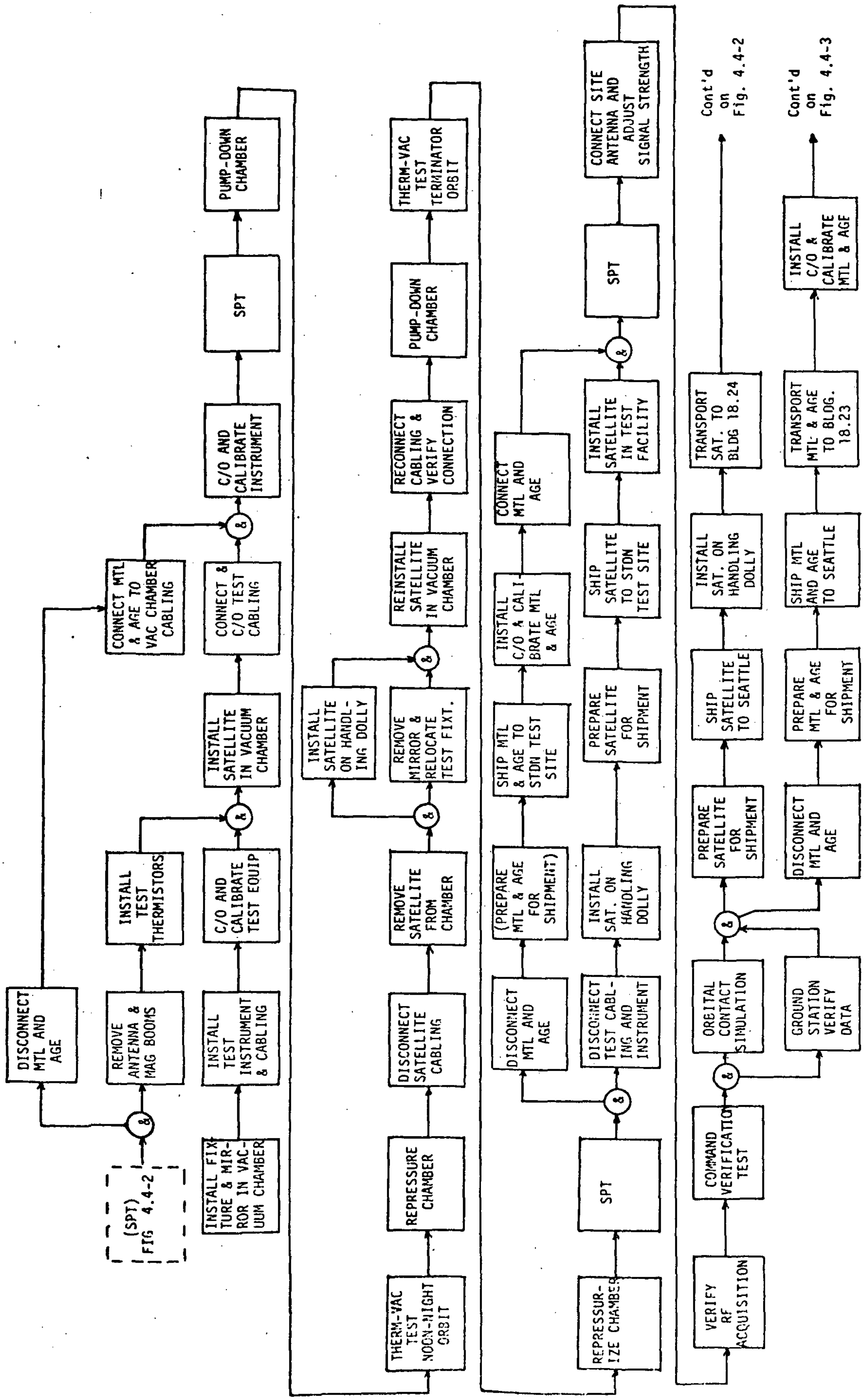

FIGURE 4.4-4: FUNCTIONAL FLOW DIAGRAM - CATEGORY II, THERMAL-VAC & STDN COMPATABILITY TESTING

and discrepancies, if any, will be analyzed. The model will be improved and agreement between prediction and test will be verified.

Power subsystem current and voltage data will be recorded during orbital simulation runs and solar array output derived. This data will be used to determine the average output power.

Main bus voltage will be monitored to ensure that it stays within limits (24.5 to 32 volts for normal orbital operation), subject to correction for off-nominal test conditions.

4.4.2.12 STDN Compatibility (First Satellite Only).

Purpose. To verify that the satellite has the ability to receive RF commands from ground stations and that STDN can receive satellite transmitted data and decode it properly.

Configuration. The satellite will have all equipment installed except ordnance and thermal insulation. Solar panel installation will be optional. The satellite will be powered by a power supply during test. The test battery will not be installed.

Test Description. The compatibility tests will consist of three parts: RF Acquisition, Command Verification and Orbital Contact Simulation. All tests will be under the direction of the Boeing Test Conductor who will be located with the satellite. The RF acquisition involves the MTL and satellite located at the test facility, and the NASA ground station at TBD. The satellite transmitter and receiver are connected to the test site antenna and sample signals are transmitted for signal strength adjustment to give reliable satellite signal reception for the remainder of the tests. Command signals are in turn received and the level is adjusted for proper signal strength to the satellite command receiver.

The second test, command verification, is used to verify that the satellite will respond to real time commands. Only selected samples of magnitude commands will be sent during the test. The MTL will be used to verify each command is received correctly and the satellite responds correctly. While the command verification tests are being conducted, the ground station will verify proper receipt of the word replica from the satellite telemetry system and the valid or invalid discrete as applicable.

The final set of tests will simulate an orbital contact and will exercise the satellite in the following operational modes to assure compatibility:

a. Receive Commands - Transmit 16 Kbps data.

b. Receive Commands - Transmit 16 and 131 Kbps data.

c. Receive Commands - Transmit 16 Kbps data and wide band data.

d. Receive Commands and Tracking Signal - Transmit 16 and 131 Kbps or wide band data and tracking tone.

e. With processor shut down, receive and transmit tracking tone.

During the various combinations of tests, the satellite subsystems and payloads will be operated wherever possible in their orbital mode. All commands to the satellite will be sent on direction of the Boeing Test Conductor. The MTL will be used to monitor and verify satisfactory operation of the satellite and the ground station will confirm satisfactory reception and decommutation of the satellite telemetry signal. At the same time, the ground station will verify their program for their various data reduction modes. Magnetic tapes of the test data will be prepared which will be available for later exercising of software.

4.4.2.13 Deployment Tests.

a. Boom Deployment.

Purpose. To verify deployment time and rotational force margin, and antenna alignment following deployment.

Configuration. The test configuration will consist of the satellite with flight payloads and equipment components installed. Mass simulated spin motors and thermal blanket installation will be optional.

Test Description. The satellite will be installed on the deployment separation test fixture with the antenna boom supported by a spring-cable counter-balance system to simulate zero-g condition. Alignment in the deployed position will be adjusted to the specified tolerances prior to deployment testing. The antenna release mechanism will be mechanically initiated. Functional operation of the boom deployment springs and stops will be verified. Deployment spring margins and antenna alignment repeatability will be measured. The test will be performed a minimum of two times to verify repeatability.

b. Solar Array Deployment.

Purpose. To verify deployment force margin, deployment time and alignment with satellite axis following deployment.

Configuration. The test configuration will consist of the satellite with flight payloads and equipment components installed. Mass simulated spin motors and thermal blanket installation will be optional.

Test Description. The satellite will be installed in the deployment separation test fixture with the array supported by a spring-cable counter-balance system to simulate zero-g conditions. Alignment in the deployed position will be adjusted to specified tolerances prior to deployment testing. The array will be mechanically released. Functional operation, deployment springs, and stops will be verified. The test will be performed a minimum of two times to verify repeatability and alignment.

4.4.2.14 Final Mass Properties Test.

Purpose. To perform the final balance adjustment and verify by analysis that the satellite mass properties will meet the requirements for all flight conditions. Test data will be used to verify:

a. Satellite weight.

b. Center of gravity (static balance) in the injection and on-orbit configurations.

c. Spin axis alignment (dynamic unbalance) in the injection and on-orbit configurations.

d. Moment of inertia (MOI) about two orthogonal axes.

Configuration. The satellite will have all payloads and flight components installed except spin motors which will be mass simulated. All deployable devices will be in their stowed positions.

Test Description. The spin fixture will be installed on the spin balance machine, balanced and aligned. The satellite will be installed on the spin fixture and the static and dynamic unbalance about the required axes will be determined. Ballast and trim weights will be adjusted to obtain static and dynamic balance using ballast locations available on the satellite structure.

a. Injection MOI

The satellite and spin fixture will be transferred to an MOI machine and the period of oscillation measured. The satellite will be removed from the fixture and the period of oscillation of the fixture will be measured. Satellite moment of inertia will then be calculated.

b. Transverse MOI

Satellite MOI in one transverse axis will be determined in the same manner as for injection MOI.

c. Weight

The satellite will be placed on scales and the weight determined and entered in the satellite weight and balance log book. Miscellaneous loose parts, such as EED's, that are not installed will be weighed and entered in the satellite weight and balance log.

4.4.3 DEMONSTRATION TESTS (3-AXIS STABILIZED)

The 3-axis stabilized BSRM will be subjected to the identical Category II test program defined in Figures 4.4-1 through 4.4-3 for the spin-stabilized vehicle. Changes in test procedures will be incorporated to account for the different AC&D subsystem hardware and associated satellite operation. Acceptance testing

will also be identical for each unit. Thermal vacuum testing will be conducted on the first 3-axis stabilized vehicle to verify differences in thermal control between the 3-axis and spin stabilized configurations.

4.4.4 ACCEPTANCE TEST

Purpose. To verify that all performance and configuration requirements are satisfied before delivery to the customer.

Configuration. The satellite will be complete including payloads except for satellite ordnance.

Test Description. Before starting final satellite acceptance testing, all discrepancies that occurred during previous testing will be resolved and all resulting retesting will have been completed. Satellite and payload sensors with critical alignment requirement including magnetometer, sun and earth sensors, will have been rechecked with respect to the satellite reference axes. Realignment will have been made where necessary to meet the requirements. The acceptance test will include a simulated flight which will be essentially the same as the flight simulation described in paragraph 4.4.2.3. Additional tests such as ordnance safing, RF power output, battery trickle charging and tape recorder storage capacity tests will be performed.

The following tests will be performed to verify satellite aliveness:

a. Aliveness of solar panels will be verified by individually illuminating each panel and verifying presence of voltage on the solar array bus.

b. Sun sensor aliveness will be verified by providing a trigger pulse, illuminating the sun sensor and verifying a sun presence signal on telemetry.

c. Earth sensor aliveness will be verified by stimulating the sensor with a warm radiating body and observing earth sensor output polarity on telemetry.

d. Magnetometer output level switching will be verified by stimulating the magnetometer test coils with a function generator and verifying corresponding magnetometer output levels on telemetry.

During the acceptance test, housekeeping data will be monitored at the MTL to verify that the subsystems are operating within tolerance limits. After completion of the test, the satellite/payload safing plug will be installed and the battery charged using a trickle charger. The satellite will then be shipped to the launch site.

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5.0 EMC CONTROL PLAN

This plan describes Contractor's approach to control electrical and electronic interference, thus ensuring electromagnetic compatibility (EMC) in the BSRM program. It is intended to provide the EMC design criteria and program implementation as required by the Statement of Work.

The governing specification for the BSRM program EMC is MIL-E-6051D of which paragraph 3.3 is used in the preparation of this plan. The performance limits and requirements shall be defined for equipment by MIL-STD-461A and the electrical bonding requirements shall be defined by MIL-B-5087B. The establishment of a 6 dB safety margin for all satellite and payload equipments in Category I and II and a 20 dB safety margin for all Electroexplosive Devices (EED/s) is specified.

Interference control shall be implemented through proper design and subsequently verified through analysis and test. The Boeing Company shall analyze and assess the MIL-STD-461A test procedures and results for all BSRM electrical/electronic packages. The assessment will result in a determination of data applicability to system integration EMC control. EMI data deficiencies shall be identified to the customer with recommended action.

Interference control verification and the associated EMC demonstration shall be accomplished with the BSRM system EMC test. The test will be conducted on each deliverable satellite.

5.1 REFERENCES

The following documents, drawings, standards and specifications shall form a part of this control plan to the extent specified herein.

(a.) MIL-E-6051D, Military Specification Electromagnetic Compatibility Requirements Systems, dated 7 September 1967.

(b.) MIL-STD-461A, Military Standard Electromagnetic Interference Characteristics, Requirements for Equipment, dated 1 August 1968, and subsequent Notices 1, 2, and 3.

(c.) MIL-STD-462, Military Standard Electromagnetic Interference Characteristics, Measurement of, dated 31 July 1966, and subsequent Notices 1 and 2.

(d.) MIL-B-5087B (ASG), Military Specification Bonding, Electrical, and Lightning Protection, for Aerospace Systems, dated 15 October 1964, and Amendment -1, dated 6 February 1968.

(e.) AFMTC 80-2, PAMPHLET VOLUME I, General Range Safety Plan, dated 1 October 1963.

(f.) MIL-STD-833 (USAF), Military Standard Minimization of Hazards of Electromagnetic Radiation to Electroexplosive Devices, dated 31 July 1963.

(g.) MIL-STD-454C, Military Standard General Requirements for Electronic Equipment, Requirement 1, dated 29 May 1969.

5.2 EMC ORGANIZATION AND TASKS

The EMC organization for the BSRM program shall be composed of engineers from the Electronics Technology EMC staff. Personnel of the EMC staff have experience on past Burner II and STP programs, in addition to having a wide range of experience in the EMI/EMC field. Each of these engineers will have the range of experience required for his specific task assignment.

The EMC organization will be supported by technicians from the electronics development shop. Technicians assigned to support BSRM will have the skills required for the operation of special EMI measurement instrumentation and will have experience in EMI/EMC test conduct.

The EMC tasks for the BSRM program have been summarized and presented in the following paragraphs. Tasks that are the responsibility of GFE personnel will be so designated and all others not so identified as to be performed by the contractor. These tasks are based on satisfying the specific requirements of the applicable military and governmental specifications for EMI and EMC requirements.

5.2.1 MEETING SUPPORT AND PARTICIPATION

(a.) Preliminary Design Reviews
(b.) Critical Design Reviews
(c.) Technical Interchange Meetings
(d.) EMC Board Meetings
(e.) Acceptance Reviews
(f.) Technical Design Reviews

5.2.2 ANALYSES

(a.) Conduct EMC analysis on the total system. The analysis will cover the following items: Grounding, RF compatibility, spacecraft electrical interfaces, spacecraft/AGE interfaces and launch environments.

(b.) Conduct analysis as required to assess impact of proposed revisions to specification requirements.

5.2.3 DESIGN SUPPORT AND REVIEW

(a.) Review and consult on grounding, shielding, bonding, wiring, and filtering for Boeing and vendor design.

(b.) Identify areas of noncompliance with EMI control requirements and initiate appropriate corrective action.

(c.) Review and approve vendor and experimenter EMI control plans, test plans, and test reports.

(d.) Review and approve interfacing wiring drawings and control documents with regard to EMI and EMC requirements.

(e.) Coordinate and assist in information exchange with Experiment contractors on EMC testing and integration.

(f.) Coordinate and assist in technical interchange with vendors regarding EMC design and testing.

5.2.4 DOCUMENTATION PREPARATION

(a.) Update and maintain the Electromagnetic Compatibility Plan.

(b.) Prepare EMC Analysis Report.

(c.) Prepare EMI Test Plans and Procedures and Test Reports for Boeing built equipment.

(d.) Prepare EMC Test Plans and Procedures and Test Reports for the system.

5.2.5 TEST CONDUCT AND SUPPORT

(a.) Conduct EMI tests on Boeing built equipment.

(b.) Conduct EMC tests on system.

(c.) Conduct engineering evaluation tests as required to support EMC design.

(d.) Monitor vendor EMI test conduct and facilities as required.

5.3 EMC BOARD

An Electromagnetic Compatibility Board (EMCB) shall be established to govern all aspects of system EMI and EMC. The provisions of MIL-E-6051D, paragraph 3.1.1, shall apply as interpreted herein.

The permanent members of the EMCB shall be as follows:

(a.) System Integration Manager - Boeing
(b.) Technical Staff Manager - Boeing
(c.) Customer Representative
(d.) Engineering Design Managers (As Required)

Temporary members may be in attendance as requested by the Board to support Board functions. Payload contractor representatives shall be invited as required. The EMC Board shall be chaired by Boeing and co-chaired by the Customer.

The EMCB shall have the direct responsibility for resolving and conflicts between the requirements delineated in this plan and other program design requirements. All requests for deviations from the established baseline EMI requirements shall be documented by the requesting agency and presented at a fully-authorized meeting of the EMCB. The deviation requests and approvals shall be numbered consecutively as they are received, for proper identification. Approval of baseline EMI deviation does not constitude approval of deviation from the 6 dB EMI Safety Margin requirements.

The EMCB shall meet at PDR, CIDR and hold additional meetings as required.

5.4 EMI TESTS

These tests to be performed at the equipment/subsystem level will verify the adequacy of interference control and suppression inherent in the various equipment items as designed. Laboratory test data will substantiate and supplement EMI analytical results. Both will be used in the planning stages of the system EMC tests. The specific application of a particular MIL-STD-461A test for the BSRM systems will be defined after program go-ahead.

EMI tests will be performed on qualification units where these units are built for other qualification tests. For equipment that is to be qualified by similarity except for EMI, the EMI tests may be performed on flight hardware provided that internal components are selected to withstand MIL-STD-461A test levels without damage.

5.5 EMC TESTS

These tests will be performed at the satellite system level on an integrated system in accordance with requirements of MIL-E-6051D. The test will verify the 6 dB margin of safety at critical points in the satellite system. Tests will be performed on all satellite configurations. The subsystems, equipments, and experiments shall have been tested to the requirements of an EMI specification and the test data results available to Boeing prior to system EMC test.

A summary of equipment EMC status and evaluation shall be prepared. The completed evaluation sheets will be included in the EMC Analysis Report. Where deviations are required, the evaluation sheets will be submitted to the EMCB for resolution.

5.6 DESIGN REQUIREMENTS

The design requirements and constraints detailed herein are established to ensure electromagnetic compatibility for the BSRM. The requirements apply to all Boeing equipment, vendor equipment and payload contractor equipment. These requirements shall be implemented by closely coordinated design monitoring.

The Boeing EMC personnel shall review designs of Boeing units, vendor units, and Government furnished experiments to identify potential EMC problems early in the program time flow for facile implementation of required corrective action.

The criteria specified below is in accordance with the requirements of paragraphs 3.2.2 through 3.2.14 of MIL-E-6051D.

5.6.1 SUBSYSTEM/EQUIPMENT CRITERIA CRITICALITY

The subsystems/equipments for the BSRM have been divided into three criticality categories, as requested by paragraph 3.2.2 of MIL-E-6051D.

5.6.1.1 Category 1 Equipment. The definition of Category 1 equipment is: "EMC problems that could result in loss of life, loss of vehicle, mission abort, costly delays in launch, or unacceptable reduction in systems effectiveness." The following are to be grouped in Category 1 equipment:

(a.) Processor, PCM
(b.) Command Decoder
(c.) Relay Box
(d.) Earth Sensor
(e.) Magnetometer
(f.) Timer
(g.) Receiver/Demodulator
(h.) Tape Recorder
(i.) Baseband Assembly Unit
(j.) Voltage Limiter
(k.) Sun Sensor
(l.) Transmitter
(m.) Amp-Hour Meter
(n.) Ordnance (EED's & Motors)
(o.) Experiments

5.6.1.2 Category II Equipment. The definition of Category II equipment is: "EMC problems that could result in injury, damage to vehicle, or reduction in system effectiveness that would endanger success of mission." The following are grouped as Category II equipment:

(a.) Test Data Van
(b.) Magnetometer Field Simulator
(c.) Payload Electrical Simulators
(d.) Command & Control Test Set (CCTS)

5.6.1.3 Category III Equipment. The definition of Category III equipment is: "EMC problems that result only in annoyance, minor discomfort, or loss of performance that does not reduce desired system effectiveness." The following are grouped as Category III equipment.

(a.) Squib Simulator and Ordnance Test Set
(b.) Earth Sensor Stimulator
(c.) Sun Sensor Stimulator

5.6.2 DEGRADATION CRITERIA

The degradation criteria shall be established for each subsystem/equipment/experiment. In establishing this criteria, emphasis shall be placed on those functions where EMC problems could compromise primary mission objectives. These criteria shall be used to define and evaluate malfunctions, and unacceptable and undesirable responses. When available, the results of subsystem/equipment

laboratory EMI tests shall be used in establishing or defining the degradation criteria. The definitions of malfunction, unacceptable response, and undesirable response shall be as stated in paragraph 6.2 of MIL-E-6051D. The specific criteria shall be presented in the EMC test plan for the BSRM program.

5.6.3 INTERFERENCE SUSCEPTIBILITY AND CONTROL

Interference generation and susceptibility within the system shall be controlled by design provisions. This shall include, but not be limited to, elimination of undesired responses and emissions from all subsystems and equipment.

Subsystems/equipment shall be designed to meet the requirements of MIL-STD-461A, as required by paragraph 3.2.4.1 of MIL-E-6051D. EMI test conduct and setup shall be in accordance with the provisions of MIL-STD-462.

5.6.3.1 Interference Generation. It shall be a system requirement to generate a minimum amount of electromagnetic interference commensurate with the system operational technical requirements. Interface driving circuits shall have strict rise and fall time control to minimize the contribution of undesired signals to adjacent wires and circuits. Impulsive noise sources such as relays and relay contacts shall be suppressed. Sepcial emission control shall be in force on the spacecraft transmitter.

The application of MIL-STD-461A upon all equipment items, whether made or purchased provides a measure of control on undesired interference emanations. Vendor control plans and test plans will be reviewed to ensure that proper and adequate controls are being utilized and that proper test methods are being used to provide design verification.

5.6.3.2 Susceptibility Control. It shall be a system requirement that susceptibility thresholds be a minimum of 6 dB above the level required to cause sufficient circuit, component, or equipment degradation that will perturb system operation. The initial effort in examining and controlling susceptibility is the application of MIL-STD-461A upon all satellite equipment. With the importance of weight in spacecraft fabrication, susceptibility shall first be controlled to the largest possible extent by electrical/electronic design and then by the techniques of shielding or physical isolation from interference sources.

5.6.4 WIRING AND CABLE DESIGN

In accordance with the requirements of paragraph 3.2.5 of MIL-E-6051D, procedures are herein established by which the various electrical conductors shall be placed in categories. The general determination of placement is based on the type of signal carried and thus the interference or susceptibility characteristics are predictable.

Categories of signal or power carrying wires are established as follows:

CATEGORY	CIRCUIT TYPE 1 DESCRIPTION
1	Alternating Current Power
2	Direct Current Power

CATEGORY	CIRCUIT TYPE 1 DESCRIPTION
3	Discrete Command Signals
4	Digital Data and Signals
5	Analog Data and Signals
6	Radio Frequency and Video Signals
7	EED Initiation Power

Table 5.6-1 is the tabulation of the categories and subcategories that may be found in the BSRM wiring design.

5.6.4.1 Cable Internal Shielding. Where conductors carrying signal or power must be routed within the same physical cable, extreme caution must be exercised in the use of shielding to prevent degrading crosstalk or mutual interference from occurring. Table 5.6-2 presents a matrix of precautionary constraints that must be employed for cable internal shielding practice.

5.6.4.2 Cable Overall Shielding Rules. The following shielding rules define which cables require shielding and how the shields are to be grounded.

RULE 1: All analog signal cables feeding wideband (DC to 100 KHz) receiver circuits, such as analog to digital converters, high gain amplifiers, etc., shall have an overall shield. Analog signal cables feeding narrowband (DC to 100 Hz) receiver circuits such as D'Arsonval meters do not require shielding.

RULE 2: All digital signal cables feeding transient sensitive electronics shall have an overall shield.

RULE 3: All excitation power and measuring power cables shall have an overall shield.

RULE 4: All video signals shall be routed in coaxial or shielded cables.

RULE 5: All RF signal cables shall be braided coaxial as a minimum; triaxial cable or solid outer conductor may be required in special cases.

RULE 6: Magnetic shielding is not required on any known circuit.

RULE 7: All shields shall be multiple grounded to chassis except shields of instrumentation circuits of 10 millivolts or less full scale, which shall be singly grounded at the end where the circuit is grounded.

RULE 8: All EED initiation power shall be routed in cables and bundles that contain no other signal or power wiring of any sort.

5.7 ELECTRICAL POWER

The overall system requirement to ensure EMC is that the EMI on the power bus shall be at a level that is at least 6 dB below the level that will cause

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TABLE 5.6-1 - POWER AND SIGNAL GROUPS

SUBGROUP	CIRCUIT TYPE/DESCRIPTION
	GROUP 1 - AC POWER
1.1	AC Excitation
	GROUP 2 - DC POWER
2.1	Single Ended, $>$ 5V, Positive or Negative DC
2.2	Single Ended, $>$ 5V, Positive and Negative DC
2.3	DC Measuring and Excitation, Source Grounded
	GROUP 3 - DISCRETE SIGNALS
3.1	28V, Mechanical Switch, Relay, Single Discrete
3.2	28V, Mechanical Switch, Relay, Multiple Discretes
3.3	5V, Mechanical Switch, Semi-Conductor Load, Single Discrete
3.4	5V, Mechanical Switch, Semi-Conductor Load, Multiple Discretes
	GROUP 4 - DIGITAL SIGNALS
4.1	Parallel, Risetime $>$ 1 Microsecond
4.2	Parallel, Risetime $<$ 1 Microsecond
4.3	Serial, Risetime $>$ 1 Microsecond
4.4	Serial, Risetime $<$ 1 Microsecond
4.5	Serial, Logic Level Change $>$ 20V

TABLE 5.6-1 (Continued)

SUBGROUP	CIRCUIT TYPE/DESCRIPTION
	GROUP 5 - ANALOG SIGNALS
5.1	0 - 5V, Balanced, Wideband, Single Analog
5.2	0 - 5V, Unbalanced, Wideband Single Analog
5.3	0 - 5V, Balanced, D'Arsonval Type, Single Analog
5.4	0 - 5V, Unbalanced, D'Arsonval Type, Single Analog
5.5	0 - 5V, Balanced, Wideband, Multiple Analogs
5.6	0 - 5V, Unbalanced, Wideband, Multiple Analogs
5.7	0 - 5V, Balanced, D'Arsonval Type, Multiple Analogs
5.8	0 - 5V, Unbalanced, D'Arsonval Type, Multiple Analogs
	GROUP 6 - RF AND VIDEO SIGNALS
6.1	Video, 100 KC, Double Grounded
6.2	Video, 100 KC, Balanced
6.3	RF, 100 KC, Single Ended
	GROUP 7 - EED INITIATION
7.1	28V, Electroexplosive Device Initiation

TABLE 5.6-2 - SHIELDING DESIGN CONSTRAINTS

GROUP	GROUP	6 RF AND VIDEO SIGNALS	5 ANALOG SIGNALS	4 DIGITAL SIGNALS	3 DISCRETE SIGNALS*	2 DC POWER*	1 AC POWER*
1	AC POWER*	NO SPECIAL SHIELDING REQUIRED	SHIELD BOTH 1	SHIELD BOTH 1	SHIELD 5V DISCRETES & AC EXCITATION ONLY	SHIELD AC & DC EXCITATION & DC MEASURING ONLY	SHIELD AC EXCITATION ONLY
2	DC POWER*	NO SPECIAL SHIELDING REQUIRED	SHIELD BOTH 2	SHIELD BOTH 2	SHIELD 5V DISCRETES & DC EXCITATION & MEASURING POWER ONLY	SHIELD DC EXCITATION & MEASURING POWER ONLY	
3	DISCRETE SIGNALS*	NO SPECIAL SHIELDING REQUIRED	SHIELD BOTH 3	SHIELD BOTH 3	SHIELD 5V DISCRETES ONLY		
4	DIGITAL SIGNALS	NO SPECIAL SHIELDING REQUIRED	SHIELD ANALOG ONLY	SHIELD 5V DIGITALS ONLY			
5	ANALOG SIGNALS	OK ONLY IF SHIELDED ANALOG IS TO D'ARSONVAL MOVEMENT	NO SPECIAL SHIELDING REQUIRED				
6	RF & VIDEO SIGNALS	NO SPECIAL SHIELDING REQUIRED					

*AC AND DC POWER AND DISCRETE SIGNAL CIRCUITS ARE ASSUMED TO HAVE ON/OFF TRANSIENTS

LEGEND

1 EXCEPTION - SHIELD NEITHER IF THE ONLY AC POWER TO BE CABLED IS AC EXCITATION POWER

2 EXCEPTION - SHIELD NEITHER IF THE ONLY DC POWER TO BE CABLED IS DC EXCITATION OR DC MEASURING POWER

3 EXCEPTION - SHIELD NEITHER IF THE ONLY DISCRETE SIGNAL(S) TO BE CABLED IS 5V DISCRETE SIGNAL(S)

4 EXCEPTION - NO EED INITIATION CIRCUIT WIRING SHALL BE ROUTED WITH ANY OTHER WIRING

malfunction, degradation of performance or unacceptable response exhibited by the particular equipment supplied with the prime power. The transient power surge and the power line ripple level limitations that each equipment item shall withstand is shown in Figures 5.7-1, 5.7-2, and 5.7-3. In addition, the requirements MIL-STD-461A shall apply.

5.8 GROUNDING AND BONDING

The BSRM system and equipment shall comply with the grounding and referencing design constraints contained herein. There are four categories of ground or referencing connections to be utilized:

(a.) Power Reference
(b.) Signal Reference
(c.) Command Reference
(d.) Shield Reference

The single point ground concept will be used for the BSRM.

5.8.1 POWER REFERENCE

The power distribution system shall be electrically isolated from the spacecraft structure by a minimum of one megohm at D.C. before connection to the single point ground. The single point ground shall be selected on the spacecraft structure and there shall be no other structural D.C. path to the prime spacecraft power system. Power return leads shall be treated as electrically hot wires and isolated accordingly. The structure shall not be used to carry power return currents for any application. Secondary power within any particular equipment package may be referenced to chassis only if such connection does not compromise any portion of these total grounding criteria and the chassis shall be connected to the spacecraft structure.

5.8.2 SIGNAL REFERENCE

Signal returns may be tied to structure at more than one point as necessary to accommodate special equipment requirements. There shall be a minimum of one megohm D.C. isolation between signal and power returns.

5.8.3 COMMAND REFERENCE

This category of reference termination may overlap into either of the two previous ground definitions. In the instance when a commanded function is initiated by a discrete pulse, it might be construed to be a "signal". For the commanded function, it is the application of power to a module or equipment item which could be construed to be a "power" system function. By either definition, the return leads for command functions shall be treated as electrically hot leads and be connected to structure at the single point ground location only. The return leads shall be isolated from structure by a minimum of one megohm at D.C. before connection to the single ground point.

FIGURE 5.7-1: TRANSIENT OVER/UNDER VOLTAGE LIMITS

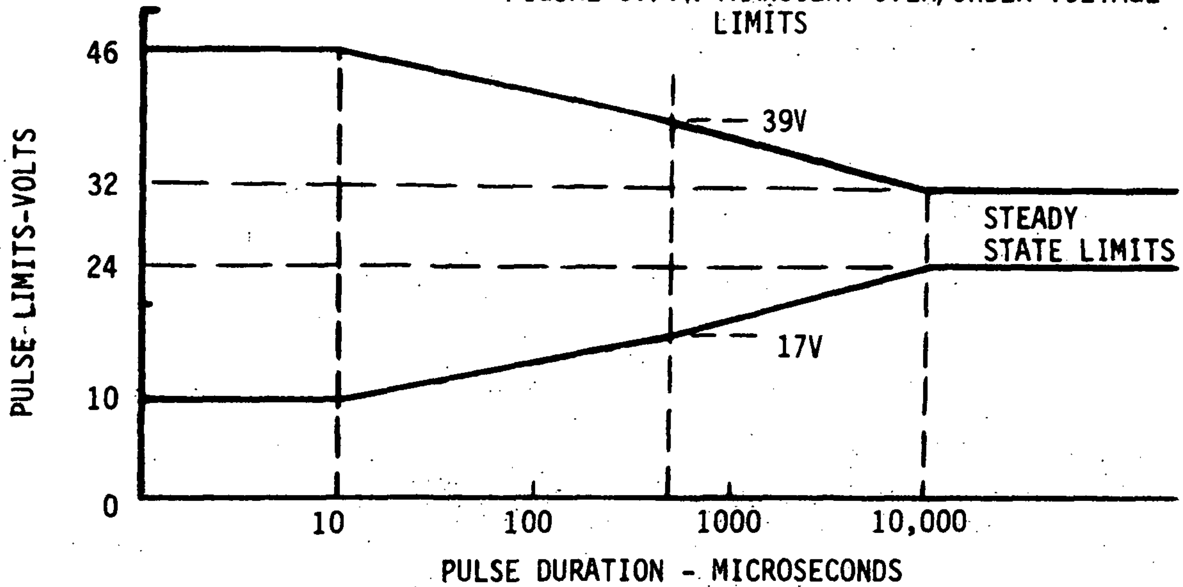


FIGURE 5.7-2: POWER LINE RIPPLE

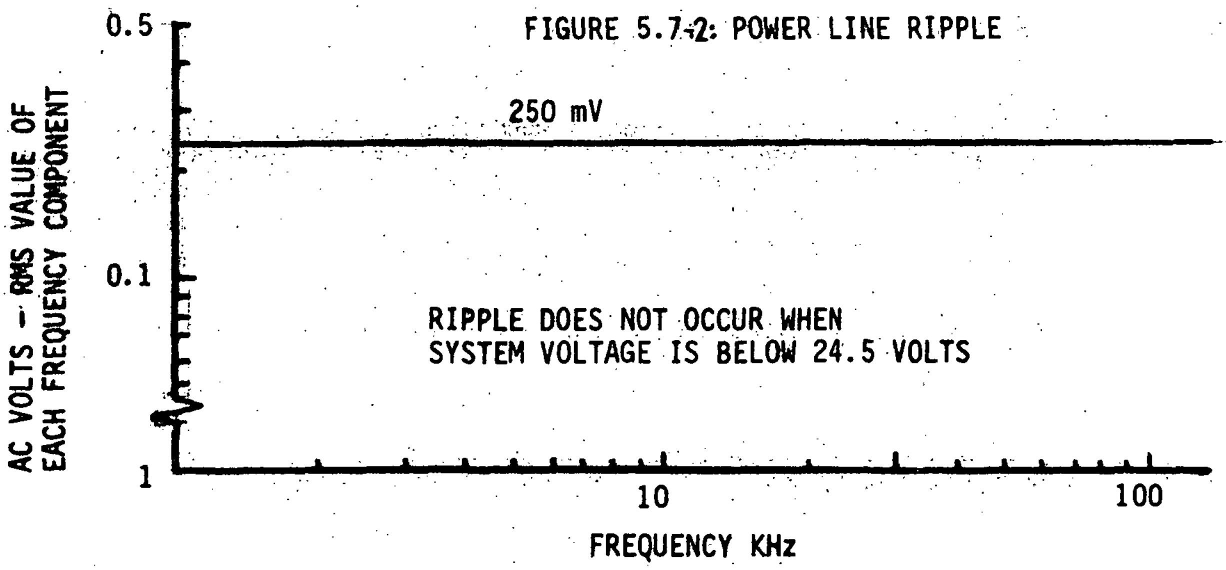
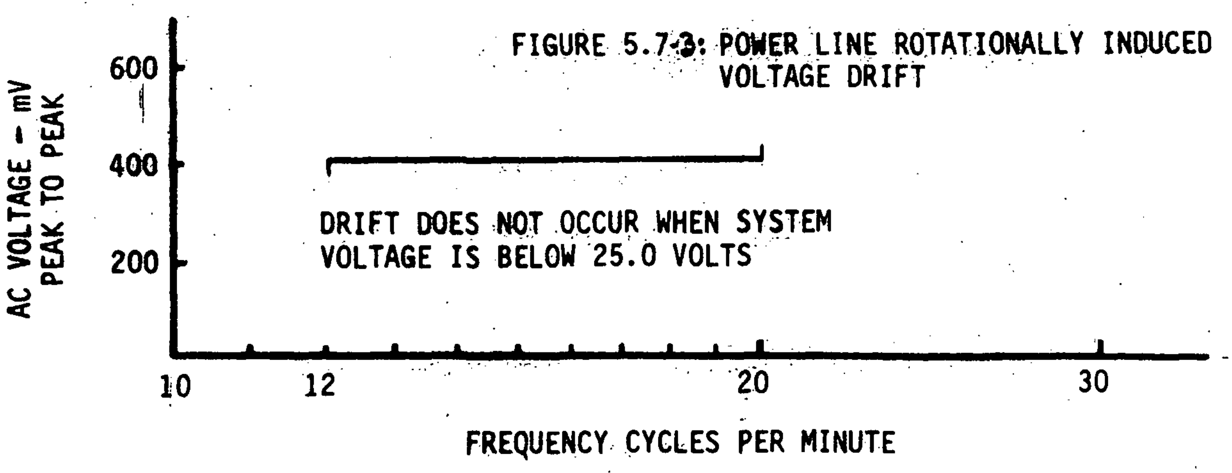


FIGURE 5.7-3: POWER LINE ROTATIONALLY INDUCED VOLTAGE DRIFT



5.8.4 SHIELD REFERENCE

Wire pairs that have an individual shield for that pair alone shall be normally terminated at one end only. Peripheral termination (i.e. 360 degree contact) at the connector backshell is recommended for all circuits that require an overall shield on a wire bundle. The overall shield shall be terminated at both ends of the cable.

Electroexplosive device or ordnance device initiation circuitry wires shall be on twisted shielded pairs that have a double braid shield. The shields shall be terminated peripherally at each end of the cable.

If an individual shield is brought out to a pigtail for termination, the length from shield connection to terminal or connector pin shall not exceed 1 inch. Individual shields may be commoned at a connector pin for the purpose of passing through a bulkhead.

5.8.5 BONDING

Bonding of the BSRM electrical/electornic equipment cases shall be accomplished in accordance with paragraph 3.3.5 of MIL-B-5087B. Bonding of equipment enclosures, whether jumpered or otherwise, the selection of materials shall be made to minimize the possibility of corrosion. Aluminum surfaces to be bonded shall have surface finishes in accordance with Table II of D2-82610.

5.9 LIGHTNING PROTECTION

No requirement for lightning protection shall be imposed on spacecraft equipment design.

5.10 STATIC ELECTRICITY

All isolated conducting items having dimensions greater than three inches, and carrying fluids or other static producing flowing materials, shall be bonded in accordance with the provisions of MIL-B-5087B.

5.11 PERSONNEL HAZARD

The basic system design shall include provisions that minimize or eliminate, where possible, all hazards to personnel that will be involved with the operation and test of the BSRM electrical/electronic equipment items. Suitable warnings shall be provided in test procedures for all transmitting sources capable of producing RF field at frequencies and levels that are potentially dangerous to personnel in the area of operation. High voltage circuits and associated cabling shall provide suitable protection to prevent inadvertant contact of personnel that will provide a conducting path between the high voltage and structure or ground. The electrical/electronic equipment shall comply with the requirements of MIL-STD-454C, Requirement 1 Safety.

5.12 ELECTROMAGNETIC HAZARD TO EED'S

All BSRM EED's shall comply with the requirements of applicable launch sites and the electromagnetic field intensity requirement of 100 watts per square meter as specified in paragraph 3.3 of Appendix A to AFMTCP 80-2 (October 1963 edition). These requirements shall also apply to the EED initiation circuitry.

The experiment contractors shall perform an EED analysis to verify the satisfaction of the above requirement for each experiment where EED's are employed. Supporting RF sensitivity data will be required for the EED's.

The Boeing Company shall perform an EED analysis to verify the satisfaction of the above requirements for spacecraft EED's and associated circuitry and EED cabling to the experiments. The results of these analyses shall be included in the Design Analysis Report for each satellite.

5.13 EXTERNAL ENVIRONMENT

The satellite shall be capable of operation in the specified RF external environment of the applicable launch area. The tabulation of sources, frequencies, and field intensities will be defined after contract go-ahead.

5.14 SUPPRESSION COMPONENTS

Suppression components shall be designed to provide a minimum safety margin of 6 dB. All relays shall include suppression devices.

5.15 ELECTRICAL CONNECTORS

Connectors shall have a conductive finish on the back shell and shall have provisions for peripheral termination and overall shields. Connector pin to chassis termination leads shall be two inches or less in length.

6.0 CONTAMINATION CONTROL PLAN

This plan describes the contamination control requirements and procedures for the Boeing Small Research Module. The purposes of this plan are:

- o Provide effective contamination prevention and control during all fabrication, assembly, integration, test and launch support phases of the BSRM program.
- o Ensure that contamination control considerations are incorporated into the BSRM spacecraft from the initial design onward.
- o Ensure that contamination control measures are properly integrated into all manufacturing, test, transportation, and launch procedures.

The requirements, procedures, and facilities to be used in compliance with this plan have been developed and successfully used by Boeing on previous NASA and USAF satellite programs. All degrees of contamination control have been implemented from conventional factory fabrication to stringent interplanetary vehicle cleanliness. Detail approved operational procedures are available and all personnel are intimately familiar with their requirements.

Key features of this plan are:

- o Contamination control will be implemented for BSRM only to the degree required to meet requirements. Excessive controls, stringent inspection techniques, and use of expensive facilities are avoided to keep program costs minimized.
- o Contamination prevention and control will be an on-going effort on the part of all organizations and will be a task intimately integrated with all aspects of the BSRM program.

This plan is organized into two sections: Part I deals with the BSRM contamination control requirements, planned techniques, and facilities to be used; Part II presents detail procedures and cleaning methods to be employed on the BSRM while at the Boeing Space Center and the launch site.

PART I

6.1 BSRM CONTAMINATION CONTROL

The requirements, facilities and control techniques described below will be implemented for the BSRM program defined in this document.

6.1.1 REQUIREMENTS

6.1.1.1 Equipment Items. All components procured for the BSRM will be fabricated and tested in accordance with the contamination control procedures normally implemented at the supplier's facility for fabrication of the specific component. Prior to closing a "black box", a visual inspection of the box interior will be performed to ensure absence of any foreign materials. In addition, the following contaminants will be controlled by existing supplier techniques:

- o Introduction of harmful chemical vapors or fumes will be prevented. The supplier will control all solvents, adhesives, paints, cleaning agents and such, for use on or around the hardware.

- o The effects of RF and magnetic fields will be considered and appropriate steps taken to eliminate the sources or minimize their effects.

Before introduction into a controlled clean work area, all equipment items will be closed to the external environment and the exterior cleaned using approved cleaning agents to ensure absence of all particulate contaminants. While being transported between work areas, the hardware will always be protected from any particulate or chemical contaminants.

6.1.1.2 Base Module Assembly. Detail parts and structural assembly work will be accomplished in conventional factory areas. Parts and assemblies will be cleaned per existing approved procedures and moved into a FED-STD-209A Class 300,000 area where final assembly, equipment installations and electrical testing will be conducted.

6.2 CLEAN FACILITIES

The Boeing Space Center complex at Kent consists of the following facilities for spacecraft assembly and test:

a. Class 300,000 Room;

b. Class 100,000 Room;

c. Class 10,000 Horizontal Laminar Flow;

d. Numerous Class 100 downflow tents and clean benches

Figure 6.2-1 summarizes the Space Center facility floor plan. All clean facilities will be monitored regularly and will be certified before initial use. All personnel involved in clean-room work are certified for knowledge of and competence in clean room disciplines and procedures. All clean rooms are identified as limited access areas. The clean areas are controlled to Boeing Specification Support Standard BSS 7001, which is traceable to FED-STD-209A and T.O.00-25-203.

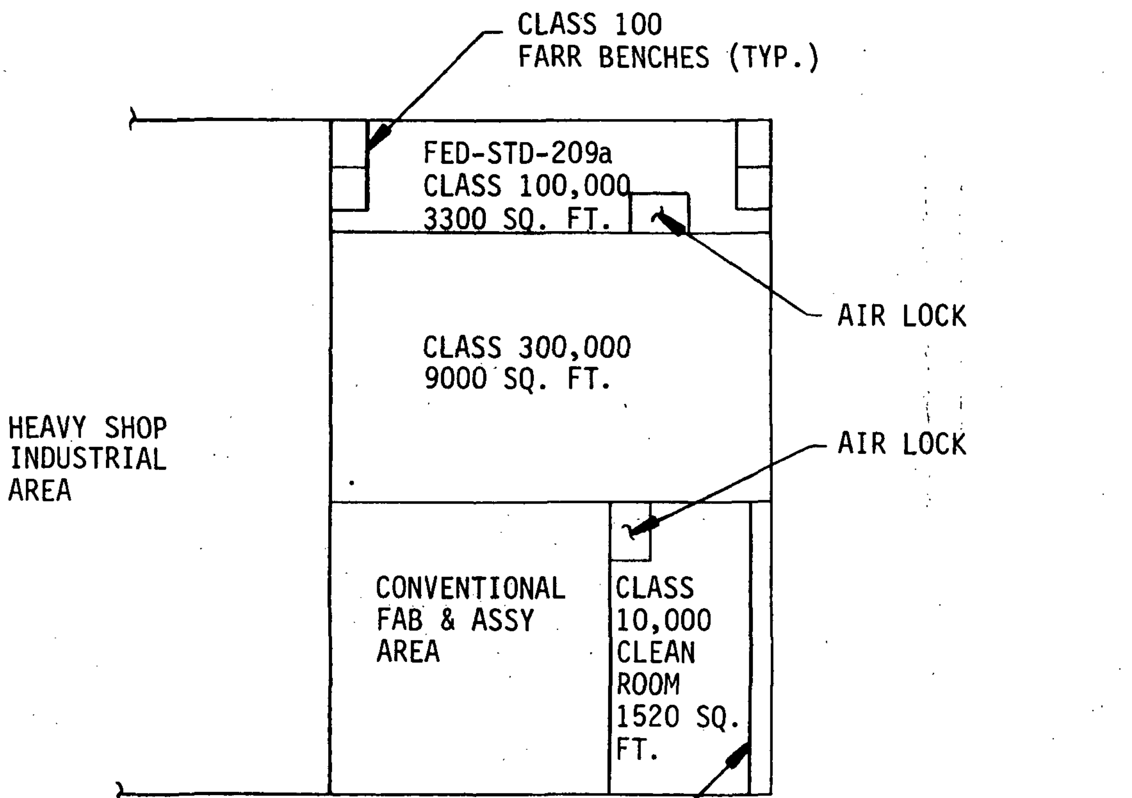


FIGURE 6.2-1:
BOEING CLEAN ROOM FACILITIES

6.3 CONTAMINATION CONTROL TECHNIQUES

To implement this plan for the BSRM, Boeing will adhere to the concepts and controls outlined below and summarized in Figure 6.3-1.

6.3.1 SPACECRAFT CONTAMINATION CONTROL

During assembly and test of the BSRM spacecraft, detail procedures will control all aspects of contamination prevention, inspection and verification. The existing Class 300,000 clean room facility will be used. The facility will be monitored regularly and a continuous temperature and relative humidity

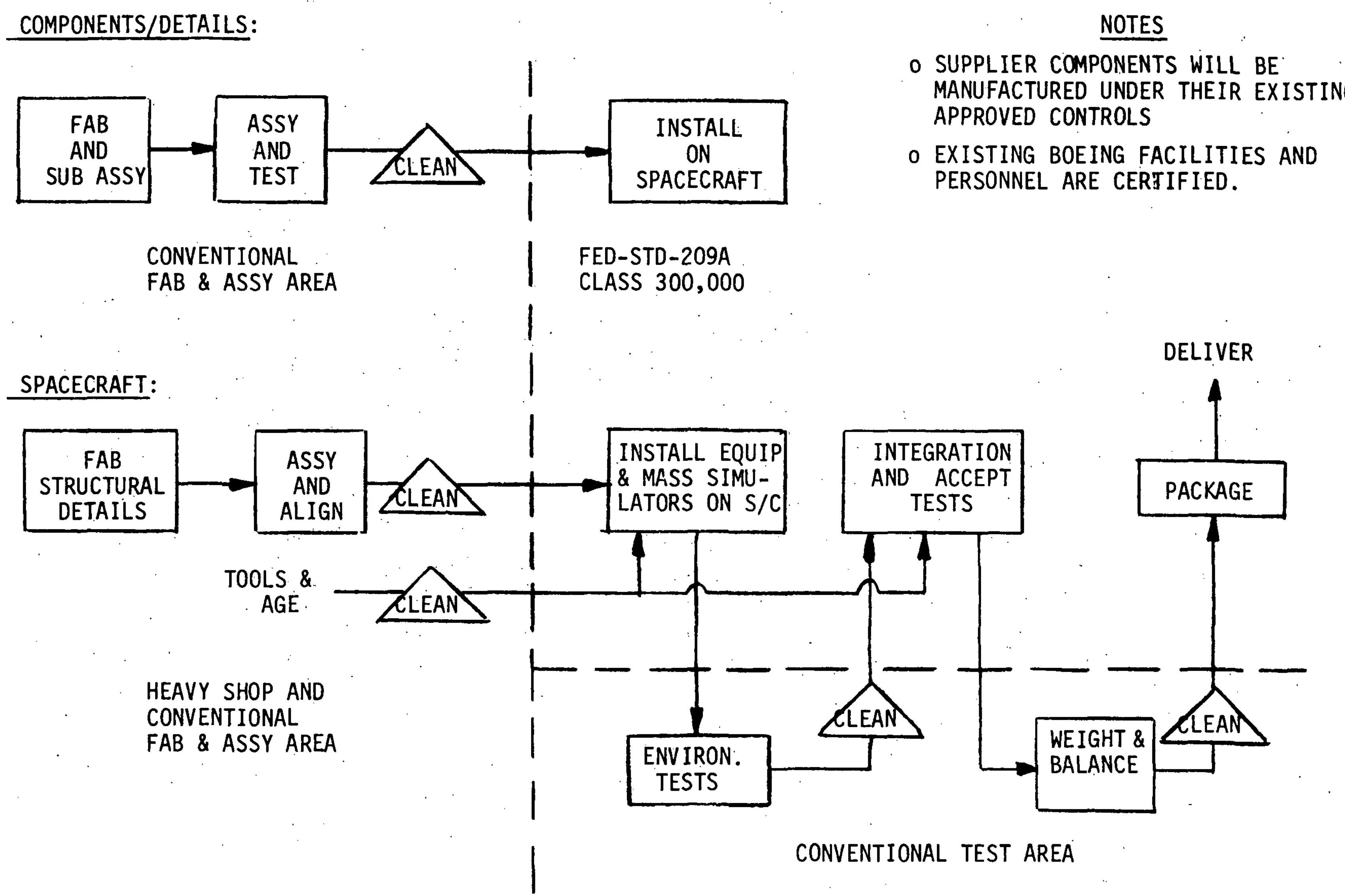


FIGURE 6.3-1

BSRM CONTAMINATION CONTROL CONCEPT

record kept. All personnel involved in clean room work are certified for knowledge of and competence in clean room disciplines and procedures. All clean rooms are identified as limited access areas.

Contractor will prepare and release a "Materials and Processes" document for the BSRM program to define the materials and processes for the spacecraft design. This document will be similar to the Burner II D2-82610 "Finishing, Marking and Color Requirements" used on Burner II, IIA, SESP and STP programs, and also similar to D233-10090-1, "Materials and Process for the Small Satellite Test Program (S3)". Only materials listed in this document will be used in the spacecraft design or to service and clean the spacecraft.

Condensible materials will be controlled through proper design. The design intent is to use only those polymeric materials that generate less than 0.1 percent volatile condensible materials (VCM) when tested by the JPL/SRI Micro VCM method or acceptable equivalent method. When qualified data is not available for desired materials, such materials will be tested by the above method in Boeing's test facility.

Propellants and fluids compatability will be verified and controlled to minimize on-orbit contamination. Cleanliness levels will be maintained through constraints on particulates. Propulsion units selected for the design will not produce any particulate larger than one micron.

6.3.2 SUBCONTRACTOR AND SUPPLIER CONTROLS

Contamination will be controlled on all purchased equipment to normal supplier procedures through requirements incorporated in the supplier procurement specification. Source control surveillance/inspection will verify compliance. The exterior of the equipment will be cleaned to spacecraft requirements. Selection of materials will be controlled by procurement specification requirements. Packaging, handling, storage, and transportation requirements will also be specified by the specification and existing supplier procedures. Contamination prevention and control capability will be verified during pre-award subcontractor/supplier survey.

6.3.3 TESTING

Contamination prevention and control during testing will be specified in the approved test procedures. Test plans and procedures developed under previous programs are applicable for BSRM. Some environmental testing must necessarily be done in conventional test areas where hydrocarbon, humidity, and temperature are controlled only as for a normal test facility as shown in Figure 6.3-1. After completion of environmental tests, the BSRM will be cleaned and inspected by approved procedures prior to being returned to the clean room. Cleaned caps will cover sensitive optics such as sun and earth sensors.

6.3.4 TRANSPORTATION AND HANDLING

The expected transportation environment will be the ambient environment associated with air and truck transportation (no rail). The spacecraft will be cleaned and placed in a shipping container, sealed in cleaned bags, and transported with monitor controls to record temperature environments.

6.3.5 AGE/TOOLS

All ancillary equipment to be used on the BSRM program will be subjected to equivalent contamination prevention and control requirements. Electrical AGE, tools and handling equipment will be cleaned to the levels consistent with the facility being used prior to entry to that facility. Existing procedures, cleanable standard AGE/GHE and cleanable tools will be utilized. All tools will be degaussed prior to use for magnetic cleanliness control. All new AGE/GHE designed for BSRM will consider the required cleanability criteria.

6.3.6 PROCEDURES

Detail procedures for implementation of this plan, and for maintenance of specified cleanliness levels will be prepared and implemented to ensure satisfaction of these requirements from the design phase to on-orbit operations.

a. Materials and Equipment. Specifications will require use of approved materials and those materials will be reflected in the design by drawings and verified by design reviews. Compliance with drawing requirements will be verified by Quality Control.

b. Surface Preparation. Surface preparation and protective coating are controlled to the engineering drawing and specified by the Materials and Processes Document.

c. Personnel. Boeing clean room personnel are trained and experienced in the operations of certified clean rooms. Such personnel have acquired experience in prior contamination control programs on a variety of NASA and USAF spacecraft.

6.4 COMPLIANCE MANAGEMENT

The primary responsibility for contamination control for the BSRM rests with the Systems Integration Manager in the Engineering organization. Verification of compliance with engineering requirements is the responsibility of the Quality Control organization. Their specific tasks are outlines below.

6.4.1 ENGINEERING

The Systems Integration Manager is responsible for design and system level contamination prevention and control. He will be provided assistance in performing this function by personnel of the Material and Process Staff of the Structure Technology Organization. His responsibilities include:

- o Identify contamination control requirements and procedures.
- o Review the spacecraft design to satisfy contamination requirements.
- o Review component specifications to ensure completeness of contamination requirements.
- o Establish detail requirements for inclusion in ICD's and field support procedures.

- o Review test plans and procedures to ensure that contamination requirements and test environments are properly identified, measured, and/or controlled.

The Systems Integration Manager will assure that all specifications are reviewed prior to release with specific regard to the adequacy and completeness of contamination requirements. He will participate in the various design reviews and technical interchange/interface meetings to ensure that specified contamination requirements have been properly reflected in the design and design requirements are attainable. Material and Processes engineers will assist in these reviews. He has overall responsibility for the resolution of contamination prevention and control problems.

Frequent interfacing with manufacturing and quality engineering will permit prompt resolution of contamination prevention/control problems. The system sued at Boeing by manufacturing to correct nonconformance to drawings and procedures is the implementation of the Integrated Record System (IRS). Non-conformance to released engineering of drawings and test procedures is handled by Unplanned Event-Rejection forms. All such forms regarding contamination will be resolved by engineering and will require approval of the Systems Integration Manager. The system will be implemented during manufacturing and covers shipping, preservation, packaging, handling, testing, assembly, installation, checkout and all in-plant and field operations of the spacecraft.

6.4.2 QUALITY CONTROL

After requirements are defined in the released and approved drawings and test procedures, Quality Control personnel will verify that contamination requirements called out have been complied with. Quality Control is responsible to verify that personnel certification requirements are met during the performance of contamination critical functions.

Packaging to maintain acceptable cleanliness levels of hardware during handling, transportation and storage, and during test operations will be evaluated as part of the contamination prevention assessment by Quality Engineering. Frequent interfacing with Manufacturing and Engineering will permit prompt resolution of contamination control problems. Quality Engineering support to source control will include consultation on supplier contamination prevention or control problems supplemented, where necessary, by on-the-spot trouble shooting and problem resolution.

Existing Quality Control monitoring and verification procedures established for other programs will be implemented during the BSRM fabrication and test cycle to accomplish certification of conformance of clean room environment to required levels of cleanliness and periodic monitoring to assure continued conformance. Existing quality control procedures meet present cleanliness requirements.

Manual sampling and visual examination to determine particulate contamination will be the principal monitoring technique. Surveillance will be performed to identify and correct noncompliance of personnel with access, activity or other constraints during periods when hardware is exposed.

All monitoring and surveillance activities will be implemented through the planned events of the Integrated Record System, and are consequently subject to the same controls and reviews as are other inspections and surveillance activities. Nonconformances will be recorded as unplanned events on the Unplanned Event-Rejection forms of the Integrated Record System, and will be subject to the same corrective action disciplines as are hardware nonconformances.

6.5 FUTURE CONTAMINATION CONTROL

Boeing has existing facilities, procedures and certified personnel to implement more stringent contamination control on future BSRM spacecraft. If sensitive instruments are integrated into the module, or if future spacecraft require cleanliness levels tighter than Class 300,000, the following can be implemented with associated higher costs:

- o Class 100,000 and/or Class 10,000 rooms can be used for assembly and some integration testing.
- o Numerous Class 100 downflow tents and laminar flow benches are available for component fabrication and assembly. The Class 100 downflow tent can be moved to the high bay test facility for cleanliness control during some environmental testing.
- o Dry GN_2 purging can be used during transportation and storage of the spacecraft between test facilities and/or to the launch site.
- o More stringent inspection techniques, such as black light, magnification, freon flush, etc. can be used if required to verify particulate cleanliness to more stringent levels.

PART II

6.6 BSRM CLEANLINESS PROCEDURES

This section identifies the standard cleaning, packaging and inspection procedures available for use on assemblies, and testing equipment for the BSRM. Cleaning needed to comply with this document is restricted to exposed surfaces. Detail drawings, manufacturing planning and test procedures will reference specific methods and controls of this document when applicable to insure compliance with the BSRM contamination control requirements.

These procedures shall apply to spacecraft parts and assemblies when prepared for delivery. When tools, jigs, tests parts, etc., are to be cleaned, the information found in Table 6.6-2 can be used to determine proper cleaning procedures.

6.6.1 MATERIALS CONTROL

CAUTION

POLYVINYLCHLORIDE (PVC) MATERIALS SHALL NOT BE USED WITH THE BSRM SATELLITE DUE TO ITS DELETERIOUS OUTGASSING PROPERTY. ENSURE THAT ALL WRAPING MATERIAL, PACKAGING FILM, GN_2 PURGING HOSES, ETC. ARE NOT PVC.

All materials, solvents and cleaning items to be used on the BSRM spacecraft shall be limited to only those items listed in Table 6.6-1.

6.6.2 ENVIRONMENTAL CONTROL

Except when otherwise specified, the procedures defined herein shall be accomplished in an environmental area controlled to BSS 7001, Class 300,000.

6.6.3 GENERAL REQUIREMENTS

All machining, deburring, forming, drilling, etching and other manufacturing operations on parts and assemblies shall be accomplished prior to final cleaning and packaging. The final operation shall be a cleaning operation performed in an environment comparable to BSS 7001, Class 300,000.

6.6.4 CLEANING METHODS

The following standard methods will be used when so directed by Engineering to clean detail parts or assemblies.

6.6.4.1 Solvent Cleaning. The solvents of Table 6.6-1 can be used to solvent clean parts and subassemblies. The choice of solvents shall be as noted in Table 6.6-2. The cleaning methods shall be as shown below.

TABLE 6.6-1

ACCEPTABLE MATERIALS

a. Film, Aclar 22A, two mil minimum, General Chemical Division, Allied Chemical Corporation, Morristown, New Jersey.

b. Film, polyethylene, plastic, four mil minimum thickness.

c. Gloves, pylox neoprene surgical.

d. BMS 11-6, Trichloroethylene, Type I or II.

e. Trichlorotrifluroethane

    i. Freon TF or precision cleaning agent, Dupont
    ii. Genesolv D, electronic grade, Allied Chemical Company.

f. BMS 3-2, Type 1.

g. Naptha, TT-N-95.

h. Acetone, ACS Reagent Chemical.

i. Ethyl Alcohol, 95 percent, denatured.

j. Butyl alcohol, normal.

k. Methyl ethyl ketone, MEK, TT-M-261.

l. Cellosolve acetate.

m. Gas, nitrogen, Mil-P-27401, Type 1.

n. Clean room wipers, Wilshire Foam Products, Gardena, California.

o. Isopropyl alcohol, commercial grade.

p. Film, antistatic, plastic, RCAS-1200.

TABLE 6.6-2

SELECTION OF SOLVENTS

MATERIAL \ SOLVENT	Ethyl Alcohol	BMS 3-2, Type 1	Acetone	Methyl Ethyl Ketone	Butyl Alcohol	Trichloroethylene	Cellosolve Acetate	Trichlortri-fluorethane	Naptha	Isopropyl Alcohol
All Metals	X	X	X	X	X	X	X	X	X	X
Wire Bundle	X								X	X
Sensor Optics										X
Copper Clad Epoxy Laminate	X							X		X
Glass Epoxy Laminate	X							X		X
Silicon Rubber and Potting Compound	X									X
Viton A	X	X	X	X	X	X	X	X	X	X
Teflon	X	X	X	X	X	X	X	X	X	X
Polyvinylidene Flouride	X	X			X	X		X		X
Acrylic		X								
Urethane	X	X			X	X		X	X	X
Phenolic		X								
Solar Panels			X							
Kapton*	X		X						X	X
Beta Cloth*	X		X						X	X

*Thermal Blanket Materials

Method 1 - Apply appropriate solvent from Table 6.6-2 to the surface by dispensing from a squirt or squeeze bottle. Rub the wetted surface with a clean room wipe. Change the wipe when it becomes soiled. Repeat the pro-ess of wetting and scrubbing until the surface is clean and the clean wipe shows no soil. Dry per 6.6.4.2.a or 6.6.4.2.b as appropriate for the part or assembly. Inspect per 6.6.6. Package per 6.6.7.

NOTE: Squirt or squeeze bottles shall have terminal filters.

Method 2 - Dampen a clean room wipe with appropriate solvent from Table 6.6-2. Begin rubbing around the outside of the dirty area and work toward the center to prevent spreading of the dirt. Repeat using a clean room wipe as often as necessary. Dry per 6.6.4.2.a or 6.6.4.2.b as appropriate for the part or assembly. Inspect per 6.6.6. Package per 6.6.7.

6.6.4.2 Drying.

(a.) Wipe dry with clean room wipe.

(b.) Air dry in BSS 7001, Class 300,000 environment for one hour.

6.6.4.3 Mechanical Cleaning.

Method 1 - Thoroughly vacuum the surfaces of parts or subassemblies to be cleaned. Inspect per 6.6.6. Package per 6.6.7.

Method 2 - Blow the surfaces free of loose dirt with pressurized shop air or gas. Inspect per 6.6.6. Package per 6.6.7 Pressurized shop air or gas shall be free of oil, water, and particulates when tested per BSS 7001, Panel Spray Test.

6.6.5 CLEANING PROCEDURES

The following standard procedures will be used when so directed by Engineering to clean assemblies and components of the BSRM spacecraft.

6.6.5.1 Solar Panels. Prior to delivery, solar panels shall be cleaned as follows to remove dirt film, finger prints, etc.

CAUTION

DO NOT USE AN EXCESS AMOUNT OF ACETONE ALLOWING FREE LIQUID TO SATURATE COVER GLASS CEMENT OR BOND LINE. EXERCISE EXTREME CARE TO AVOID DAMAGE TO COVER SLIDES, CONDUCTORS, OR INTERCONNECTS. USE ONLY MODERATE PRESSURE WHEN SWABBING WITH CLOTH OR Q-TIPS.

(a.) Area of solar cells away from interconnect tabs: Solvent clean using Method 2 of paragraph 6.6.4.1. Dry per 6.6.4.2.a or 6.6.4.2.b.

(b.) Adjacent to the interconnect tabs: Solvent clean using cotton tipped Q-tips moistened with acetone. Use very light pressure, even to the extent of leaving some small amount of residue, to avoid damaging the interconnect tab compliance loops. It should be noted that these contact areas are coated with a clear thin conformal coating and may have minute particles of lint or foreign material adhering. Removal of such minute particles is not mandatory for proper function of the solar arrays. Dry per 6.6.4.2.b.

6.6.5.2 Structural Assembly. After installation of appropriate equipment, components, wirint, etc., and prior to delivery, the BSRM spacecraft shall be mechanically cleaned per Method 1 of paragraph 6.6.4.3 (Method 2 shall not be used to preclude contamination deposits in structural cracks). After vacuuming, Method 2 of paragraph 6.6.4.1 shall be used to remove dirt film, finger prints, residual cutting oils, etc. Dry per 6.6.4.2.a or 6.6.4.2.b. Do not blow dry using compressed shop air or gas.

6.6.5.3 Wire Bundles. After installation on the spacecraft, the wire bundle shall be cleaned in conjunction with the structural assembly (paragraph 6.7.5.2 above) by vacuuming using Method 1 of 6.7.4.3. Connectors, support brackets, clamps, etc., shall then be solvent cleaned per Method 2 of paragraph 6.7.4.1. Solvent cleaning of the wire braid is not required except where visible contaminate deposites are evident. Dry per 6.6.4.2.a or 6.6.4.2.b. Do not blow dry using compressed shop air or gas.

6.6.5.4 Thermal Blankets.

CAUTION

EXERCISE EXTREME CARE WHEN CLEANING TO AVOID DAMAGE TO THERMAL BLANKETS. THERMAL BLANKETS SHALL ONLY BE HANDLED WITH CLEAN SURGICAL GLOVES.

Solvent clean thermal blankets per Method 2 of paragraph 6.6.4.1 using light pressure and extreme care not to tear the blanket material, sewn edges, or cutouts. Dry per 6.6.4.2.a or 6.6.4.2.b. Do not blow dry using compressed shop air or gas. Thermal blankets shall be cleaned prior to installation on the cleaned spacecraft.

6.6.5.5 Sensor Optics. The sun and earth sensor optics and aperture covers shall be cleaned prior to delivery as follows:

(a.) Remove dust, lint and other foreigh matter by blowing air across the surface with a hand rubber syringe. Do not use compressed shop air or gas.

CAUTION

DO NOT USE POLISHING LIQUIDS, PASTES OR ABRASIVES FOR CLEANING LENSES OR SENSOR OPTICS.

(b.) If the optics are still not clean, use isopropyl alcohol, fine lens tissue paper or Q-tips and clean per Method 2 of 6.6.4.1. On large diameter optical elements, the cleaning process should start in the center of the optical element and slowly proceed to the outer edge of the optical element using a circular motion at all times. The process should not produce any streaks. Repeat this procedure until all surface dirt and marks are removed.

(c.) Dry per 6.6.4.2.b.

(d.) Clean aperture covers per Method 1 or 2 of paragraph 6.6.4.1. Dry per 6.6.4.2.a or 6.6.4.2.b.

6.6.5.6 Installation of Cleaned Hardware to Satellite. Control the installation of cleaned parts and equipment to the following requirements:

(a.) Exercise minimum handling of the cleaned hardware.

(b.) Handling tools must be cleaned with MEK or alcohol using lint-free materials.

(c.) Equipment storage bags shall be vacuum cleaned or wiped down with a clean lint-free cloth prior to bringing the equipment to the spacecraft.

(d.) Install equipment on the cleaned satellite in the Class 300,000 controlled area.

(e.) Control the number of personnel to the minimum required to perform actual assembly/test operation(s). Parallel operations are permitted.

6.6.6 INSPECTION

Surfaces of all cleaned parts and assemblies shall be visually examined for the presence of moisture, foreign material such as grease, oil, loose dirt, scale, etc. Parts which show evidence of contamination shall be recleaned. If after three (3) repetitions of cleaning and inspection, contamination is still visible, it shall be assumed to permanently imbedded in the paint or finish process and shall be considered acceptable for flight.

6.6.7 PACKAGING PROCEDURE

The following procedure will be used to package the BSRM spacecraft and any associated loose items prior to delivery.

NOTE

Polyethylene film shall be cleaned per paragraph 6.6.4.1, Method 1 or 2, prior to being used for packaging cleaned parts or assemblies. Inspect cleaned film per paragraph 6.6.6 prior to use. Cleaned parts or assemblies shall be handled with clean gloves during all packaging operations.

(a.) Insert the part, assembly, or spacecraft into a clean bag made from RCAS-1200 antistatic film or polyethylene film. Remove as much air as practical from the bag. Heat seal with a continuous 1/16 inch minimum width seam using a thermal impulse type sealer.

(b.) Place the bagged assembly inside a second bag also made from clean polyethylene or RCAS-1200 film. Remove as much air as practical from the bag. Heat seal with a continuous 1/16 inch minimum width seam using an electric sealing tool.

(c.) Affix an appropriate label or tag identifying the contents by part number and serial number (if applicable).

7.0 OPERATIONAL SUPPORT

7.1 AGE PLAN

This plan contains a description of the design and usage of the Aerospace Ground Equipment (AGE) and the Ground Handling Equipment (GHE) to support the BSRM program. Existing S3 equipment and existing Boeing capital equipment will be used to a very large extent. Functional and interface requirements for the BSRM are essentially identical to the S3 satellite. The extreme commonality with previously used AGE reduces cost and insures efficient conduct of BSRM development and acceptance test programs.

7.1.1 ELECTRICAL AGE

Electrical AGE will be provided to support functional testing of the BSRM satellite with and without payloads installed. The equipment will be entirely portable, permitting support of testing at Boeing and any Scout launch site.

Figure 7.1-1 shows a schematic of the BSRM electrical AGE and identifies the specific equipment items. All AGE shown is available from the S3 program. Two minor differences for BSRM are:

- o Additional breakout boxes may be required for the different connectors on any added subsystem components.
- o The earth sensor stimulator will be a different unit for the 3-axis BSRM version.

7.1.1.1 Mobile Test Lab. The heart of the electrical AGE system is the Boeing-owned Mobile Test Lab (MTL). This unit is a mobile command and telemetry ground station with capability to perform the following functions:

- o Receive and evaluate satellite telemetry data.
- o Record test data.
- o Transmit satellite commands.
- o Identify out-of-tolerance measurements.
- o Format and display selected test data.
- o Service operator requests for data processing, command generation and transmission, display formatting and software operation.
- o Retrieve, display, and print selected data.

The MTL contains both manual and computer controlled functional capability. It stores test procedure sequences, satellite commands and go/no-go limits in the computer memory and provides automatic execution and verification of pre-established

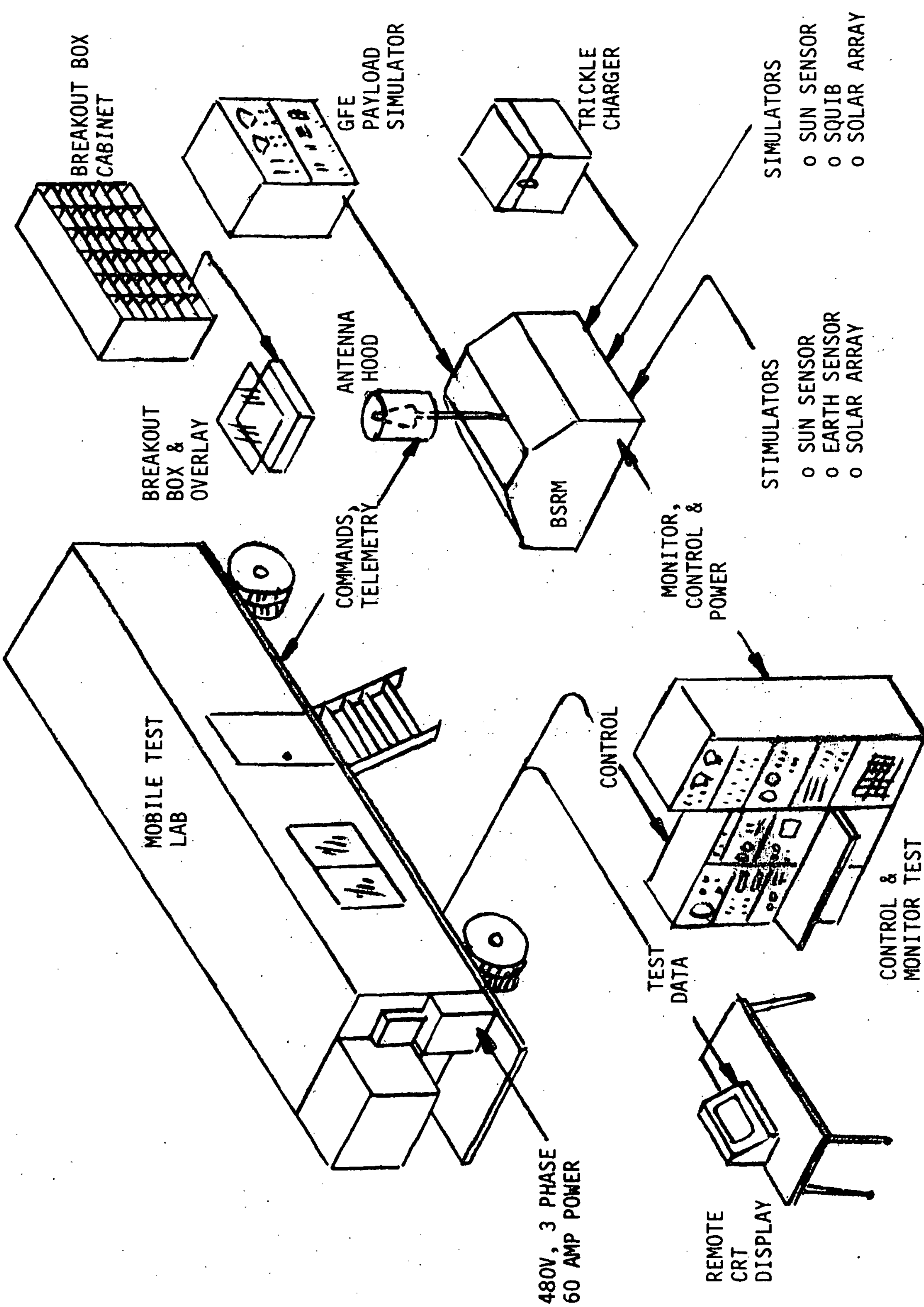


FIGURE 7.1-1: BSRM ELECTRICAL AGE

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test criteria. The similarity of S3 and BSRM subsystems will allow a large part of the S3 test procedures and computer software to be utilized without modification in the BSRM test program.

The MTL equipment is contained in an 8 foot high by 8 foot wide by 34 foot long equipment module mounted on a 4-wheel trailer. The wheels are removable for air or road mobility. Figure 7.1-2 presents a cut-away view of the van and identifies the interior equipment items.

7.1.1.2 Control and Monitor Test Set (CMTS). The CMTS is a Boeing-owned set of equipment configured for testing S3 satellites. It is contained in three standard relay racks and performs the following functions:

- o Provides electrical power to the satellite main bus and simulates solar array output.
- o TDV computer interface relay control of satellite functions (such as steppint the satellite timer).
- o Visual monitoring and alarms for critical satellite functions (such as battery voltage and transmitter temperature).
- o Manual control of satellite power, sequencing and monitoring functions during test operations.
- o Visual time monitoring of test sequences.
- o Troubleshooting with self-contained standard test equipment (oscilloscope, digital voltmeter, etc.).

The CMTS can be used essentially as configured to support the BSRM program.

Interfaces between the MTL, the BSRM, and other electrical AGE are shown in Figure 7.1-1. Controlling satellite functions not possible through the command link (such as stepping the satellite timer) is accomplished through relays in the CMTS. A remote CRT which displays computer controlled test sequences is located at the CMTS to provide visibility for the test team.

7.1.1.3 Other Electrical AGE. The following additional items are available from the S3 program to support BSRM operations with little or no modification:

Battery Trickle Charger. This unit maintains the satellite flight batteries at a full state of charge until disconnected during the launch countdown. It is housed in an explosion-proof suitcase container with visual and audible alarms which are activated if the battery terminal voltage or charge current reaches preset limits. The trickle charger would be used without modification for the BSRM.

Break-In Boxes. A break-in box was provided for each type of satellite and satellite/experiment interface connector to support special tests and troubleshooting. Each box has the capability of signal monitoring through plug-in lights and each connection can be opened or jumpered individually to provide current monitoring or individual circuit disabling. Except for some experiment break-in boxes, the S3 boxes will support the BSRM program.

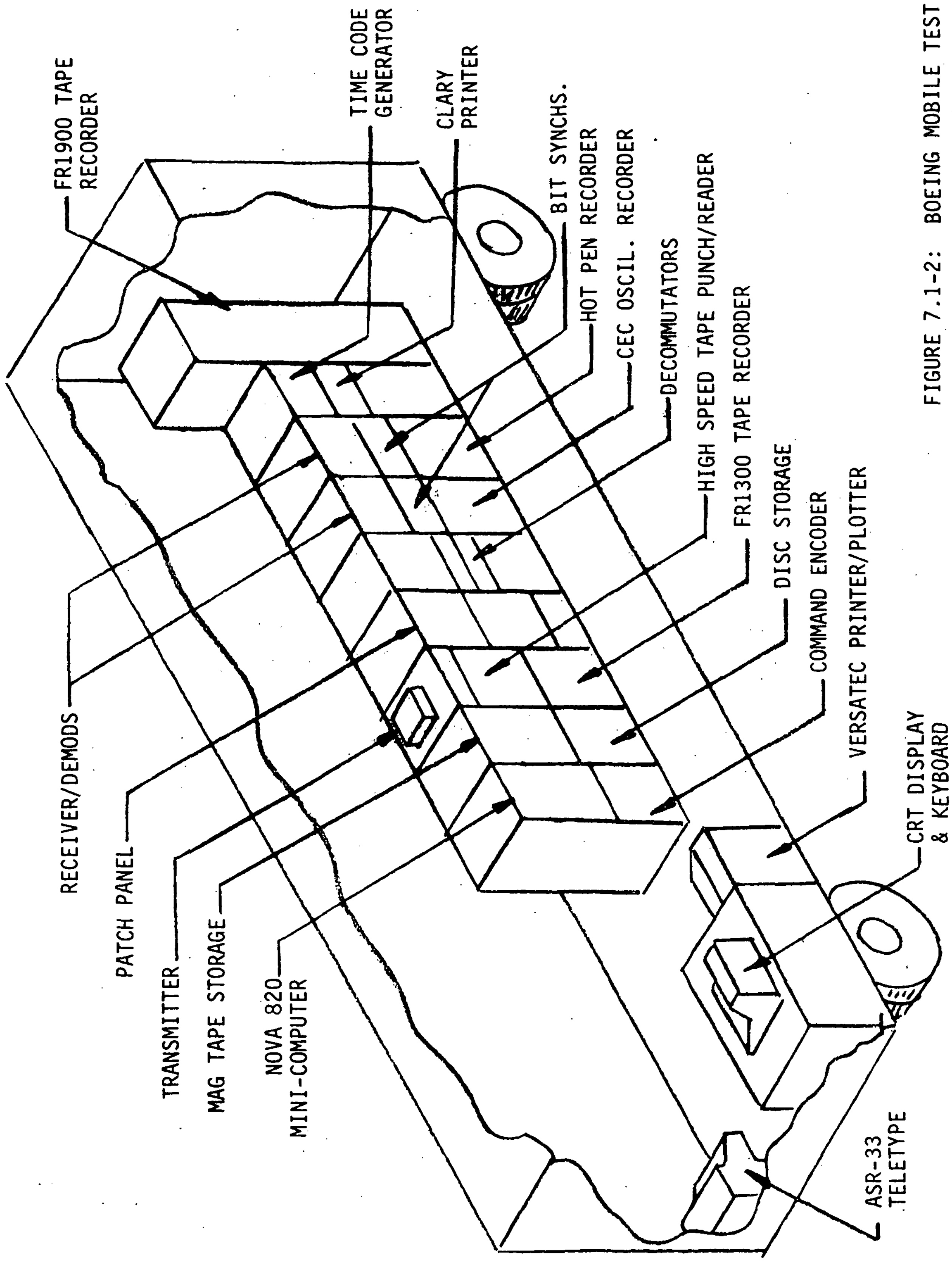


FIGURE 7.1-2: BOEING MOBILE TEST LAB

Squib Simulator. This suitcase test equipment contains circuit breakers and indicator lights to simulate satellite squib loads and verify current supply capability of squib firing circuits. The S3 program simulator with only minor modifications will support the BSRM program.

Antenna Hoods. Antenna hoods were constructed for the S3 program for open loop command and telemetry communication with the MTL. These hoods can be used for the same purpose for the BSRM antennas.

Stimulators. Sun and earth sensor stimulators and a "sun-gun" solar array stimulator are available from the S3 program to support BSRM.

Simulators. A vendor-supplied sun sensor simulator is available from the S3 program. The CMTS contains a solar array simulator (power supply) to provide power to the BSRM satellite during testing.

7.1.1.4 Payload Electrical Simulators. An electrical simulator with operating procedures will be provided by payload contractors for each payload package that interfaces with the satellite. The simulators will be used to:

- o Check out spacecraft system at the experiment interface prior to installation of flight payloads.
- o Verify proper connections to payload without risking damage to flight experiments.
- o Aid in fault isolation in the event of indicated payload malfunction.

The payload simulators will be required to duplicate experiment orbital electrical loads, indicate receipt of command, and provide termination of telemetry input circuits to the BSRM satellite. Complete requirements for the payload simulators and operating procedures will be included in the Satellite/Experiment ICD's. The payload contractor will provide support for payload installation and alignment, servicing, special monitoring, stimulation and data evaluation. Also a payload representative will generally be present when AGE is being used and the payload operated.

7.1.1.5 Launch Site AGE. The existing payload handling trailer will be required at each BSRM launch site to position the BSRM for mating to the Scout.

The MTL requires three phase, 480 volt, 60 amp. facility power. The MTL is supplied with one 30 ft. cable for power connection.

7.1.2 GROUND HANDLING EQUIPMENT

Existing GHE from the S3 program will be used to support the BSRM requirements. Minor modifications are required to some items to adapt to the Scout launch vehicle processing. The use of existing GHE results in complete flexibility of operations in test and transportation. Either vertical or horizontal installation on test fixtures can be accommodated. The following paragraphs briefly summarize the GHE:

Container/Transporter. The existing S3 transportation dolly also serves as a shipping container. Shipping shock and vibration isolation is achieved with polyurethane foam cemented between two aluminum decks. An overbox is installed on the dolly during shipping. Provisions are incorporated in the existing design for contamination control barriers filled with dry nitrogen gas.

Handling Frame. A lightweight aluminum frame is used to lift the satellite for installation onto test fixtures or the transportation dolly. Sling attachment points permit rotation of the satellite to either horizontal or vertical positions to accommodate any test orientation.

Handling Sling. A sling assembly is provided with interchangeable fittings to permit lifting of the satellite and handling frame in any orientation.

Solar Panel Containers. Supplied by the solar panel vendor for storage and transportation of the flight solar array panels. Each panel is individually packaged in non-static clean bags and purged with dry nitrogen gas to provide contamination control.

Cover - Solar Panel Protection. The solar panels will be installed on the satellite during the majority of the program. Damage to the panels during processing will be prevented by the installation of a clear hard protective cover mounted to the satellite structure. It is easily removed for satellite access, testing and flight.

Container - Battery Storage/Shipping. Each battery will have storage/shipping container. It will provide adequate protection for the battery to prevent damage during storage and shipping and be packaged in polyethylene plastic to meet the cleanliness requirements.

7.1.2.1 Payload GHE. Each payload agency will provide any unique GHE with operating procedures to meet any experiment requirements. The payload contractor will provide support for payload handling as required.

7.1.2.2 Transportation. The satellite with experiments installed will be shipped to the launch sites by air or truck (no rail) in the existing satellite container/transporter. For truck transportation, a dedicated air-ride van will be used. No shock or vibration test equipment will be required as the existing transportation dolly has been tested on the S3 program to verify that transportation loads do not exceed flight loads.

All AGE and GHE, including that provided by payload contractors, will be shipped and handled in conventional shipping containers. Standard handling equipment (fork lifts, etc.) will be used depending upon the AGE/GHE size and weight.

7.2 FIELD PROCESSING PLAN

This plan describes the operations to be conducted at Vandenberg AFB from the arrival of BSRM AGE and flight hardware through launch. All prepad operations will be performed in NASA Building 836 in South VAFB. Boeing has utilized NASA Building 836 for prepad processing of the STP P72-1 satellite and AFSCF compatibility testing of the three STP S3 satellites. The Boeing-owned Mobile Test Lab (MTL) was used at the NASA facility for computer-controlled functional testing of the S3 satellites and is proposed for similar testing of the BSRM satellites. The MTL, AGE and GHE are described in Section 7.1 of this document. The MTL will be used for on-pad satellite checkout and removed from the pad prior to the final launch countdown.

7.2.1 TRANSPORTATION TO VANDENBERG AIR FORCE BASE (VAFB)

After completion of acceptance testing in Seattle, the BSRM will be cleaned and sealed in an anti-static protective cover within the transportation/shipping dolly. The BSRM will be fully assembled except for squibs, spin motors, and solar panels, which will be packaged and shipped separately. The BSRM along with the AGE and GHE will be transported to VAFB in an enclosed environmentally controlled air-ride van. The wheels will be removed from the MTL and it will be loaded on an air-ride flatbed trailer for transportation. To minimize handling of the MTL, it will remain on the flatbed trailer until it is returned to Seattle after launch.

7.2.2 NASA BUILDING 836 OPERATIONS

The BSRM, AGE, GHE and MTL will be processed in VAFB NASA Building 836 as shown in Figure 7.2-1. The BSRM, AGE and GHE will be off loaded from the air-ride van and positioned in the area outside of the Building 836 clean room. The overbox will be removed from the BSRM transportation dolly and the BSRM on its shipping dolly will be rolled into the clean room. The protective cover will be removed and a thorough visual inspection made. Configuration of the BSRM will be verified and uninstalled hardware will be inventoried and accounted for.

In parallel with BSRM inspection and verification, the MTL will be positioned adjacent to Building 836. Facility power will be connected and the MTL will be checked out and recertified for use with the BSRM. The electrical AGE will be positioned outside the clean room, interconnected and checked out.

After the MTL and AGE have been verified, they will be connected to the BSRM and used to verify there has been no damage or degradation to the BSRM due to shipment. The functional test will be the same as the System Performance Test performed in Seattle and described in Section 4.4.2.9 of this document. Upon successful completion of this test and verification of the test data, the MTL and AGE will be disconnected and transported to the launch pad. The spin motors and squibs will be installed in the BSRM and connected after "no voltage" has been verified in the ordnance circuits. The BSRM will be visually inspected and, using a checklist, all critical items such as connections and pin removals will be verified. The thermal blankets will be closed out except for areas requiring access at the launch pad and the solar panels will be installed and

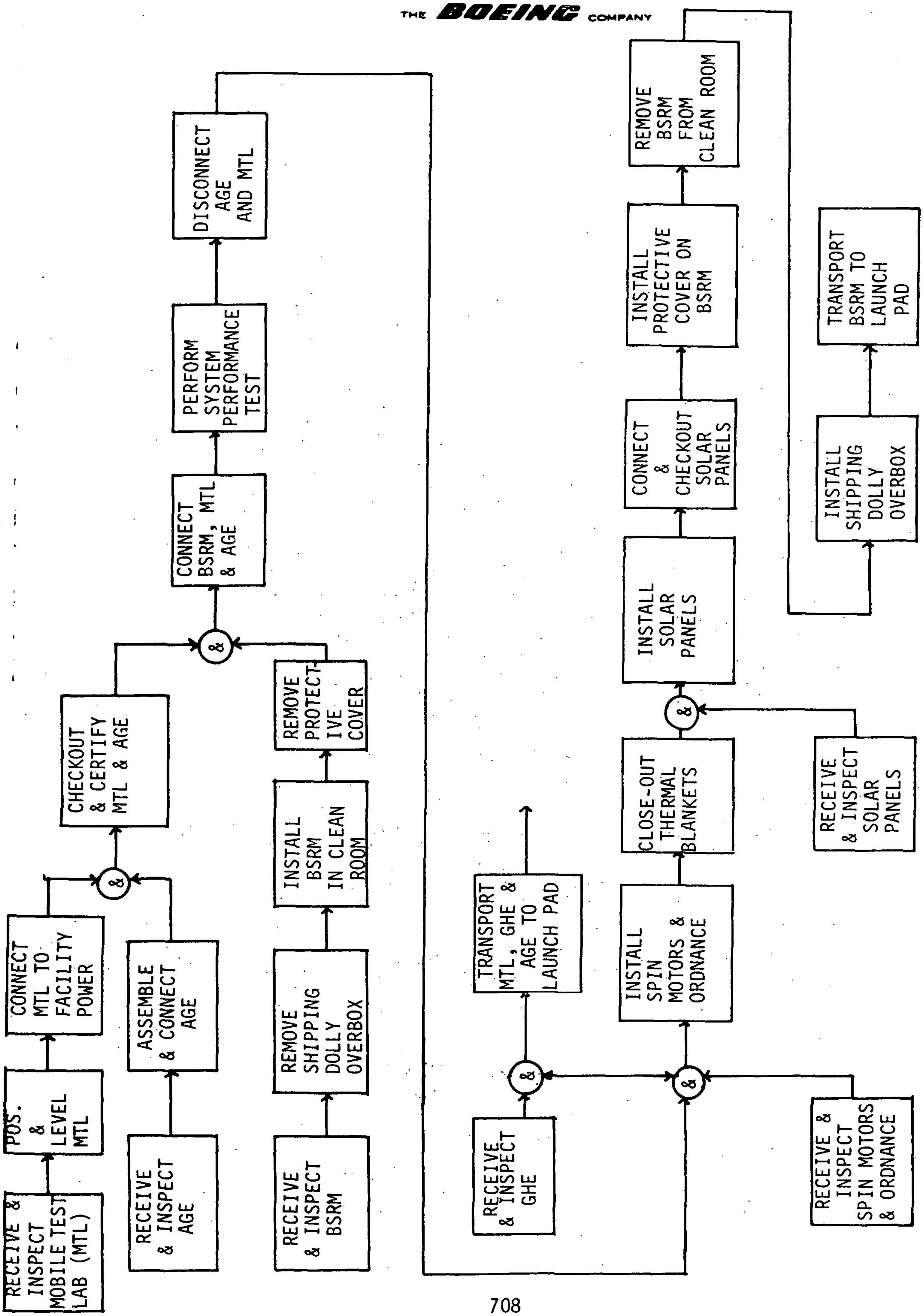


FIGURE 7.2-1 NASA BLDG 836 OPERATIONS

electrically verified. The BSRM will be cleaned as necessary and the anti-static protective cover will be reinstalled on the BSRM and sealed. The transportation dolly will be rolled out of the clean room, the overbox will be installed and the dolly will be loaded onto an air-ride trailer for transportation to the pad.

7.2.3 LAUNCH COMPLEX OPERATIONS

The BSRM will arrive at the launch complex and be off loaded from the trailer using a fork lift truck as shown in Figure 7.2-2. The transportation dolly will be moved into the movable shelter chain hoist. The BSRM will be lifted from the dolly using the GFE Payload Handling Trailer. This trailer will be used to position the BSRM for mating with the Scout Fourth Stage. After the BSRM is positioned for mating, the V-band will be installed and torqued. During V-band torquing personnel protection will be provided by using a safety strap to retain the V-band in case of a failure. The BSRM protective cover will remain on the spacecraft at all times prior to fairing installation to provide maximum environmental protection. Any access to the BSRM will be provided by cutting the cover as necessary and resealing after completion of the task. After BSRM/Scout mating is complete, the MTL and electrical AGE will be connected and a short confidence test will be performed to verify no damage has occurred to the BSRM during the transportation and handling operations. This test will exercise the BSRM subsystems and experiments to the extent necessary to verify aliveness. The MTL will be used to provide the uplink commands and to verify telemetry outputs. After the completion of this test, the battery will be fully charged and a battery trickle charger will be connected. The MTL and electrical AGE will be disconnected and removed from the launch site.

Prior to fairing installation, the BSRM protective cover will be removed and the sensor protective covers, solar panel protective covers and safing pins will be removed and final inspections and cleaning of the BSRM will be accomplished. After the fairing is installed the only BSRM activity will be to maintain the battery trickle charger and monitor battery voltage with the trickle charger. The charger will be disconnected and the arm plug will be installed as late in the countdown as practical, preferably just before erection of the Scout for launch. The accomplishment of these tasks will require a small access door in the fairing.

The above approach provides no monitoring of the BSRM during countdown. If monitoring is required by one of the payloads it can be provided through an umbilical to the BSRM and a control and monitor console in the blockhouse. If desired, the MTL could be positioned off the launch pad and used during the countdown to command the BSRM and monitor the open loop telemetry signals.

7.2.4 FIELD PROCESSING SCHEDULE

The field processing schedule is shown in Figure 7.2-3. This schedule, except for operations at the NASA Building 836, is almost totally dependent on Scout processing requirements. The only BSRM activities required at the pad are provided below with an estimate of the hours required to accomplish the tasks:

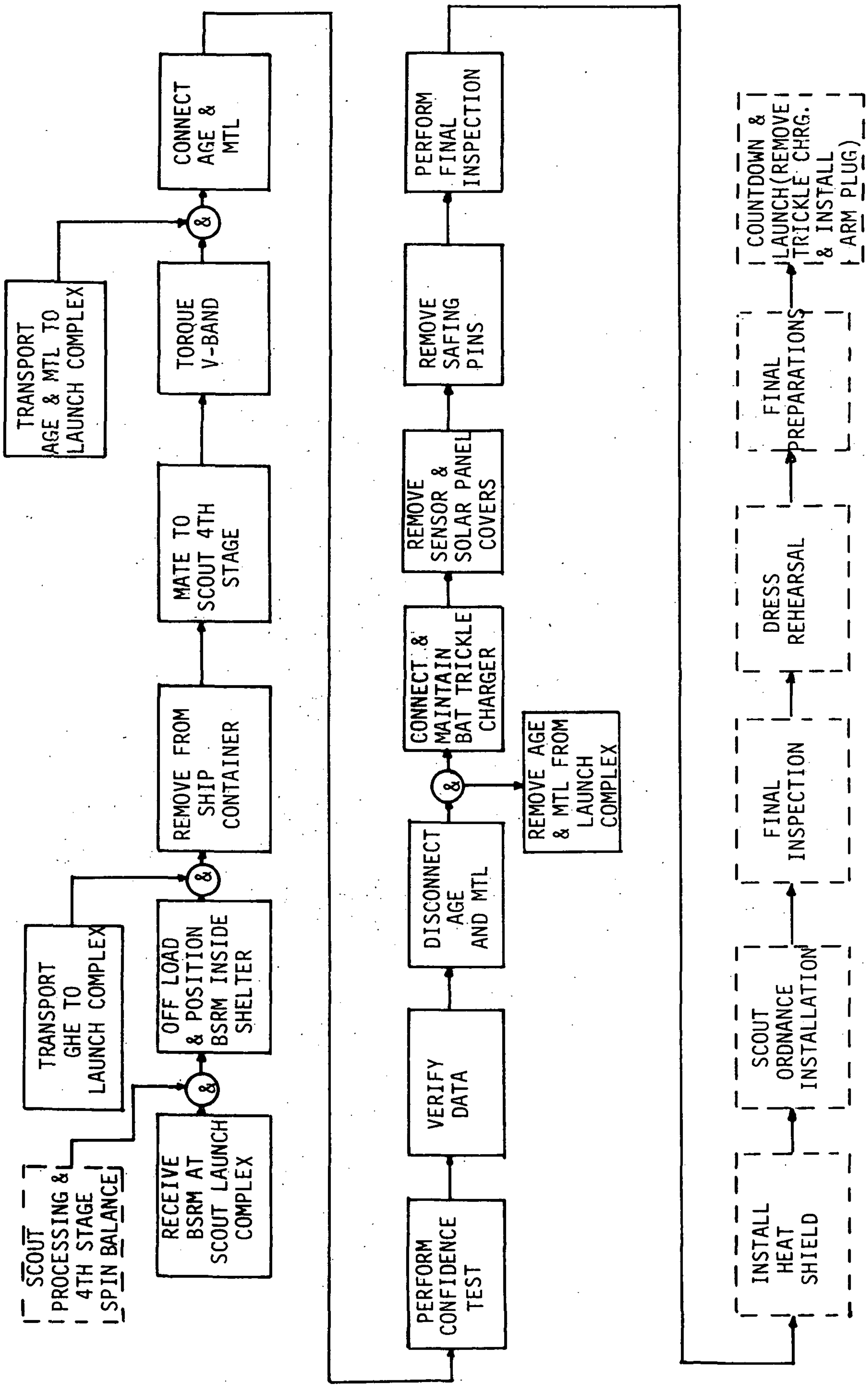


FIGURE 7.2-2 SCOUT LAUNCH COMPLEX OPERATIONS

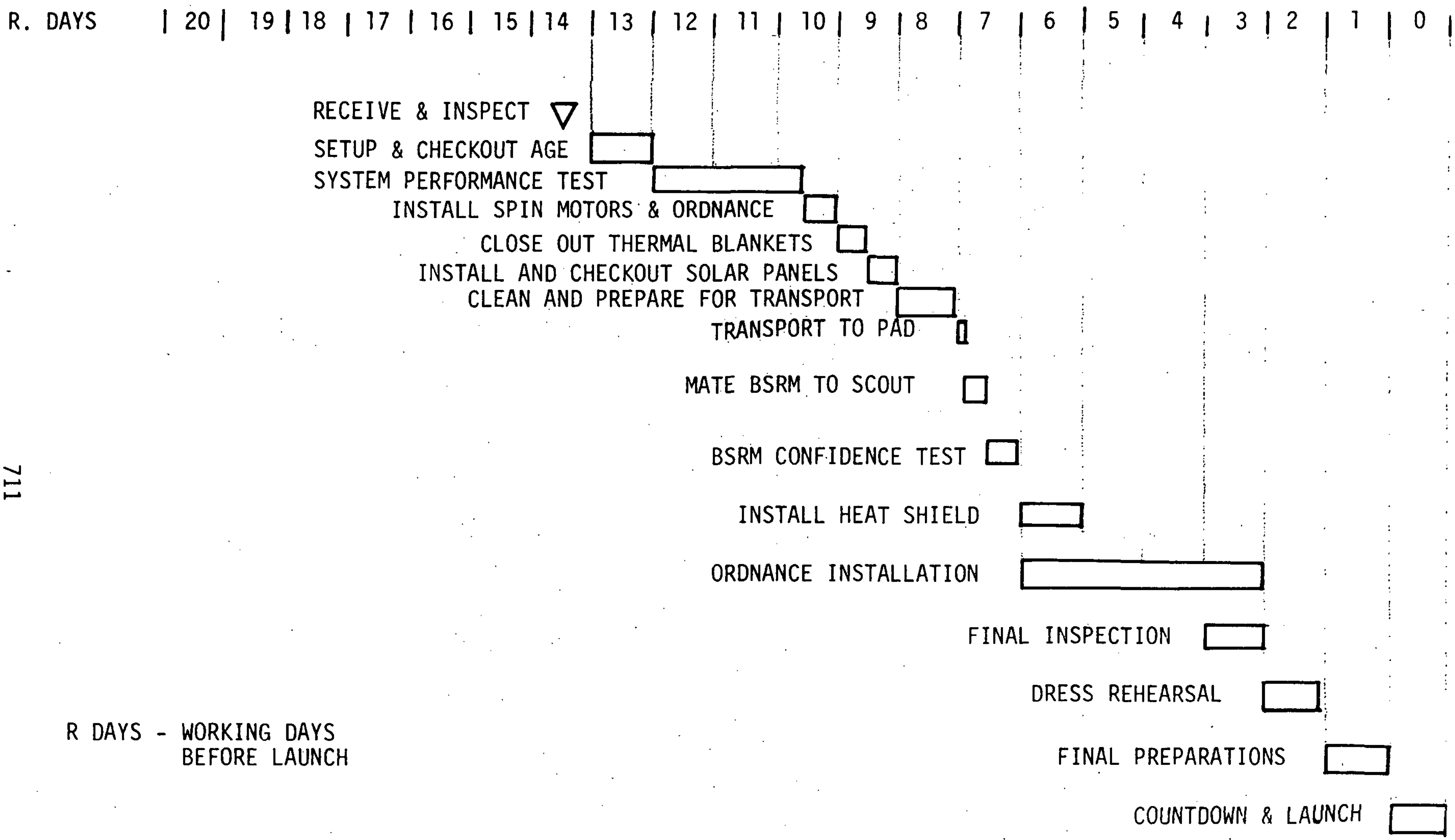


FIGURE 7.2-3 FIELD PROCESSING SCHEDULE

- o Mate to Fourth Stage - 4 hours
- o Perform Confidence Test - 4 hours
- o Prepare for Fairing Installation - 2 hours
- o Disconnect Trickle Charger and Install Arm Plug - 0.1 hours

7.2.5 FACILITY REQUIREMENTS

There are no special facility requirements other than the need for facility power at Building 836 and the Scout Launch Complex. The MTL requires three phase, 480 volt, 60 amp facility power at both locations. As there is no monitoring of the BSRM during countdown, there is no requirement for a console in the blockhouse.

7.2.6 LOGISTICS SUPPORT

The Boeing team will bring to VAFB all equipment that is needed to support Boeing operations at Building 836 and the launch complex. This includes the full complement of spares provided for BSRM support.

7.2.7 PLANS AND PROCEDURES

Boeing will provide the following plans and procedures to support the field processing activities:

- o A Field Processing Plan will be prepared to define and schedule all field activities. The plan will include organizational responsibilities, facility requirements, and logistic requirements.
- o Boeing will provide all procedures necessary to handle and test the BSRM at both Building 836 and the launch pad.
- o Boeing will provide BSRM inputs into integrated field documentation such as the countdown manual.

The Boeing documentation will include inputs from the experimenters. All procedures will be verified to the maximum extent practical during the Seattle test program.

7.3 SYSTEM OPERATION

System operation for the BSRM will use techniques proven on the STP S3 program to provide efficient experiment data retrieval. The following features provide smooth flow and versatility.

- o Tracking, data retrieval, and data processing by STDN.
- o Technical support by the BSRM design and test engineers.
- o Real time mode selections by ground command
- o Real time or delayed execution of satellite operations.

7.3.1 BOOST AND INJECTION OPERATIONS

Each BSRM is placed in orbit by the Scout launch vehicle. After fourth stage burnout, a yo-yo device despins the BSRM/stage combination. The V-band clamp is then fired separating the BSRM from the Scout upper stage. During separation of the satellite, the timer is actuated to initiate the BSRM sequence of events.

7.3.1.1 Spin Stabilized BSRM. The sequence of events for the spin stabilized BSRM after ejection is as follows:

- o Fire spin-up motors.
- o Deploy satellite antenna booms.
- o Begin quarter orbit magnetic torquing to precess the satellite spin-axis to the on-orbit orientation.
- o Switch timer from the ejection mode to the orbital mode.

These events will be completed in less than three hours after separation from the launch vehicle.

Quarter orbit torquing continues for up to 48 hours to precess the satellite spin axis. During this period of time ground commands are sent to the satellite to adjust the timer drive frequency to synchronize timer cycling with the orbital period. Housekeeping functions are monitored to verify proper satellite operation. Ground commands are sent, at the completion of spin axis precession, to release payload covers and/or deployment devices and initiate enabling functions.

7.3.1.2 Three-Axis Stabilized BSRM. The sequence of events for the 3-axis stabilized BSRM after ejection is as follows:

- o Spin up inertia wheel
- o Deploy satellite antenna boom
- o Acquire earth and sun references
- o Begin magnetic and inertia wheel torquing to establish axes orientation
- o Switch timer from the ejection mode to the orbital mode

Orientation torquing continues for up to 96 hours to align the spacecraft axes. During this period of time ground commands are sent to the satellite to adjust the timer drive frequency to synchronize timer cycling with the orbital period. Housekeeping functions are monitored to verify proper satellite operation. Ground commands are sent after axes orientation to release payload covers and for deployment devices and initiate enabling functions.

7.3.2 ORBITAL OPERATIONS

Orbital operation of experiments is accomplished by ground command and a pre-programmed timer/ground programmed relay matrix. Real time operation of an experiment is accomplished by first sending commands to enable the experiments desired and then sending a command to switch the experiment power bus from pre-programmed operation to the ON configuration.

Pre-programmed operation, using the timer, provides great flexibility in experiment operations. Timer output is programmed prior to each flight for 21 relay latching pulses per orbit; with 16 of the pulses occurring at each 22.5 degrees of orbit, and 5 pulses at the discretion of the experimenters. (Zero degrees in the orbit is referenced to any predetermined point in the orbit.) Each of the 21 latching pulses may be used to either activate or deactivate the experiment bus during the orbit. Ground command is available to enable the use of the pulses. Ground command is also used to activate the timer during one or more of six orbits following a ground contact.

7.3.3 GROUND OPERATION

Satellite ground operations are performed by the NASA Space Tracking and Data Network (STDN). This net provides ground command of the satellite and accumulation of experiment, housekeeping, attitude and ephemeris data. Satellite operations will be performed in accordance with the Orbital Requirements Document (ORD). The ORD will be updated duirng the mission to provide for changes in operating conditions or the desired mode of operation. Data transmitted from the satellite will be gathered by the remote tracking stations throughout the world. Real time data and commands will be transmitted to and from the satellite via land lines. Recorded data, transmitted from the satellite, is shipped from the remote tracking stations to the Goddard Space Flight Center.

Attitude and ephemeris are determined at Goddard. These data are then merged with the recorded experiment data, in a format compatible with the experimenters computer, to provide coordinated data. Raw data, including housekeeping and attitude, is available to experimenters upon request.

8.0 MANUFACTURING PLAN

Fabrication and assembly of the BSRM will be accomplished using low cost tooling concepts, product control procedures, and manufacturing techniques proven on previous successful Boeing spacecraft. A close working relationship between designers and manufacturing/tooling engineers has been developed in the SS&PS organization to insure low cost fabricability and minimize tooling requirements. Cleanliness will be maintained by adherance to procedures defined in the Contamination Control Plan.

Fabrication and assembly will be accomplished at the Kent Space Center in the 18-23 Building, with the exception of a few operations requiring the use of unique specialized equipment. These special shop operations will be accomplished in other company facilities where this equipment is located.

8.1 APPROACH

The SS&PS Manufacturing organization operates an organization of personnel experienced and disciplined in space oriented programs. This organization will report to and be responsible to the BSRM program manager. Realizing the manufacturing task is to produce a small quantity of critical hardware to a "tight" but attainable schedule, particular emphasis is placed on schedule control, configuration control, and cost effectiveness. A close day-to-day working relationship is maintained with Engineering, Materiel, Quality Control and Systems Test.

Schedule and cost attainment is enhanced by assembling the basic structural configuration, ground equipment, and electronic packages in our project shop. Configuration control is maintained by the use of an existing Integrated Record System (IRS) which is fully responsive to AF375-1 manuals, and was used on BII/IIA and numerous STP programs. Existing S3 program tools, jigs, procedures, planning, etc. will be extensively used on the BSRM program to minimize costs and insure meeting schedules.

8.2 FABRICATION PLAN

The BSRM structure is very similar to the existing S3 vehicle. This similarity will allow extensive use of S3 fabrication and assembly jigs and fixtures. Critical interfaces such as payload interfaces, equipment locations, and boost stage interface will be controlled to engineering requirements.

Manufacturing will make the solar panel substrates and deployment hinge mechanisms. The blank solar panel substrates will be routed to a selected vendor for application of the solar cells to the substrates. The panels with the cells attached will be returned to the project shop for installation on the structure. Solar cell testing will be accomplished by the vendor.

Boeing will fabricate some electronic assemblies, such as the relay box, antennas, electromagnetic coils, etc., as was done for the S3 program. These items will be essentially identical to the S3 hardware permitting use of planning, tools, etc. Manufacturing will conduct in-process tests and acceptance tests on each unit in accordance with existing engineering requirements.

Interfaces are controlled as for any equipment item and existing drill templates will be used where possible.

All critical hole patterns required for interchangeability will be drilled from drill jigs which are either Boeing built or vendor supplied. Where alignment of hole patterns is critical, indexing holes will be included. The payload suppliers will be required to provide an interface drill template for each of their sensors and/or electronic boxes.

After all the equipment is loaded into the structure, an optical alignment will be made on all equipment where alignment is critical. With the completion of optical alignment, the thermal control barriers and solar panels will be installed. The completed vehicle will then be released to Systems Test for completion of their functions. Manufacturing will continue to support all required testing under the Test Engineer's direction. All test activity, both planned and unplanned events, will be controlled using the IRS Configuration records.

8.3 TOOLING

8.3.1 MANUFACTURING TOOLING

These contract tools are nondeliverable items used to aid in the fabrication, assembly, test, handling, and transportation of program hardware. Existing S3 tooling will be used extensively for BSRM. Manufacturing Engineering will determine any new tooling required based on the dimensional, interchangeability, handling, and protection requirements of the BSRM spacecraft. These will be ordered by the manufacturing engineer and designed by tool designers who are also responsible for the tool's ability to perform its intended function.

Manufacturing engineers will use Boeing "standard tools" to the maximum extent possible by calling for their use in the manufacturing planning orders. Upon completion, tools are inspected and their first usage witnessed by Quality Control to ensure that the end product meets engineering design requirements.

8.3.2 FABRICATION TOOLING

These tools are used to facilitate the making of detail parts. Existing S3 fabrication tooling will be used extensively for BSRM. The philosophy for fabrication of any new tools will be to use only those necessary to control configuration, tolerances, and interchangeability. Due to the limited number of end items to make, they will be multipurpose to accomplish several functions in one position. Common, readily available material will be used for their construction to be cost effective.

Experience on other programs with similar quantities of high-value, high-tolerance parts has proven the most cost-effective approach is to rely heavily on skilled machine setups, and shop-made aids. Careful sequencing of assemblies and thoughtful consideration to assembly tooling will also assist in minizing fabrication tooling.

Manufacturing Engineering will work very closely with the designers during the early design phase in order that manufacturing considerations and tooling philosophy will be consistently applied throughout the program. This working relationship has been successful on many previous Boeing spacecraft programs resulting in a low-cost fabrication approach which is now ingrained in the design organization.

8.4 MANUFACTURING ORGANIZATION

The Manufacturing Manager is responsible to the Program Manager while maintaining a reporting relationship to the BAC Manufacturing Director. The Manager's function is to organize, set policy and provide direction for his team members. This system allows the flexibility of assigning qualified personnel between job areas to assure a timely completion of program tasks and needs.

The dedicated manufacturing organizations have highly skilled employees with an average work experience of 13 years in the building of high-reliability space hardware. These employees are selected for their extensive knowledge of manufacturing and testing techniques and for their ability to work closely with the design engineers for breadboarding effort and with the manufacturing engineers in an efficient and cost-conscious manner to produce the deliverable hardware.

8.4.1 MANUFACTURING ENGINEERING

Manufacturing Engineers are the key personnel on the manufacturing team. Their responsibility is:

- o To work with Engineering to develop an economical, reproducible design;
- o To work with Materiel to order the correct material in sufficient quantity and have it arrive in a timely manner to support schedule;
- o To work with shop personnel to fabricate and/or assemble their equipment items (using the IRS System); and
- o To report status on all phases of their equipment item to the program Industrial Engineer for summary and presentation.

This system provides for early visibility into any potential problem area to affect an immediate solution.

The Manufacturing Engineer utilizes the Integrated Record System (IRS) order to direct the activities of the project shop. The IRS order schedules the work, directs the sequencing of effort and records all activities that occur in the fabrication, assembly or testing of any given item. Unplanned events, such as rejections, are also recorded on the IRS order. Manufacturing Engineering will provide data and technical support to the BSRM Change Board through the assigned Manufacturing board member. When the Change Board has approved a change, Manufacturing Engineering initiates revised or new IRS manufacturing engineering planning based on released "changed" engineering.

8.4.2 INDUSTRIAL ENGINEERING

Manufacturing cost and schedule information is developed by Industrial Engineers, and reported to the Manufacturing Manager on a weekly basis. The Industrial Engineer develops No. 1 flow schedules from the program schedule at a Tier III level (sub-system components) with costs allocated and collected at the P/N level. Actual costs are allocated, collected, summarized and evaluated by part number at both the manhour and dollar level.

8.4.3 MANUFACTURING PLANNING

Manufacturing planning, as referred to in this plan, is a method of communication between the engineering requirements of what is to be fabricated, assembled and tested and the manufacturing shops where the actual work is performed. The purpose of this communication is to provide a set of instructions covering the required drawings, specifications, raw material, purchased parts, and sequence of operations. Manufacturing planning also provides a permanent set of fabrication, assembly and test records whereby configuration, traceability, serialazation and quality acceptance can be logically and sequentially maintained. This planning function is performed by the Manufacturing Engineers and Tool Production Planners.

9.0 CONFIGURATION MANAGEMENT PLAN

The configuration management function includes the analysis of configuration requirements, coordination with the procuring agency for proper interpretation, configuration policy direction to the functional organizations within the project, and the definition of configuration requirements for subcontractors and suppliers. This configuration management plan will provide the controls to ensure compliance with a uniform system of configuration definition, identification, control and accounting.

9.1 ORGANIZATION

The System Assurance Manager is responsible for Configuration Management. He represents the Space Support and Propulsion System Manager in all matters relating to Configuration Management for all projects assigned to the Space Support and Propulsion System Organization. The configuration management function is covered under a Customer Management Practices Staff which formulates and publishes the directives and procedures as approved by the appropriate levels of management.

The Configuration Manager has a twofold responsibility: he is responsible for keeping informed of Company Customer Management Practices and has the authority to execute those directives and procedures. He also supports the Project Manager of each project in determining the contractual requirements for configuration management and implementing company procedures to comply with those requirements.

9.2 CHANGE CONTROL

The SS&PS organization has a Design Change Control Board. This board is chaired by a designated Change Board Manager. Each of the organizations has members assigned to the Change Board. The board convenes at the request of the Change Board Manager. Any functional member of the Change Board may request a Change Board Meeting to consider any deviation to the initial commitments that may affect design schedules, budgets or contractual requirements. Each functional organization member assigned to the Change Board has the responsibility and authority to make commitments for the performance of work in his functional area.

9.2.1 SPECIFICATION PREPARATION

System and end item specifications are prepared by Engineering to provide the requirements and design criteria to meet the mission requirements. Format and presentation of requirements are coordinated with Engineering by the configuration management organization. The specifications are routed within engineering and supporting technology staffs for technical verification and approvals by affected groups. When approved by management, the specifications are placed under the control of the Configuration Management Organization and submitted to the procuring agency for approval.

9.2.2 ENGINEERING RELEASE

After approval by the procuring agency, the specifications are formally released for use through Engineering Release Control, a function of the Configuration Management Organization. Engineering is responsible for design which is accomplished by drawings prepared and released according to the requirements of the end item specification. The spacecraft baseline and the hardware design requirements baseline is established at the Configuration Item Design Review (CIDR).

9.2.3 ENGINEERING CHANGES

After CIDR any change or addition to the specifications, engineering drawings or data will be classed and controlled by the Configuration Management Organization as a Class I or Class II change. Figures 9.2-1 and 9.2-2 illustrate the controls and approvals required for Class I and Class II changes.

Class I changes and Class II changes (other than liaison type) are initiated by Engineering, using an Engineering Change Memo (ECM) which includes reason for change, technical description of change, impact on reliability, schedule, configuration, testing and performance. The ECM is routed within Engineering for verification and approval. Configuration Management Organization verifies the class and assigns a control number. The change is controlled internally by the ECM which is distributed to functional organizations (Materiel, Manufacturing, Quality Control, Finance and Contracts) prior to a Change Board Meeting. All Functional organizations participate in the Change Board evaluation of all changes to schedule and commit the change which will assure timely implementation and completion.

9.2.3.1 ECP Preparation. Class I change data is derived from the Engineering Change Memo (ECM). The Engineering Change Proposal (ECP) and the Specification Change Notice (SCN) and Specification Change Log (SCL) are prepared by Engineering Design and the Configuration Management Organization. This ECP/SCN package is approved by the Configuration Manager, the Engineering Manager, and the Project Manager, prior to submittal to the procuring agency for approval. After approval of the ECP by the procuring agency, the change is incorporated in the specifications and engineering drawings which are released for production.

The Engineering Change Memo (ECM) for a Class II change will be released for implementation when the Procuring Agency Technical Representative has verified the classification.

9.2.3.2 Change Control Administration. Once an ECP is proposed the Program Planning and Scheduling organization monitors the steps required to obtain an ECP submittal, approval, and implementation and completion. This control is documented and reviewed at periodic management meetings.

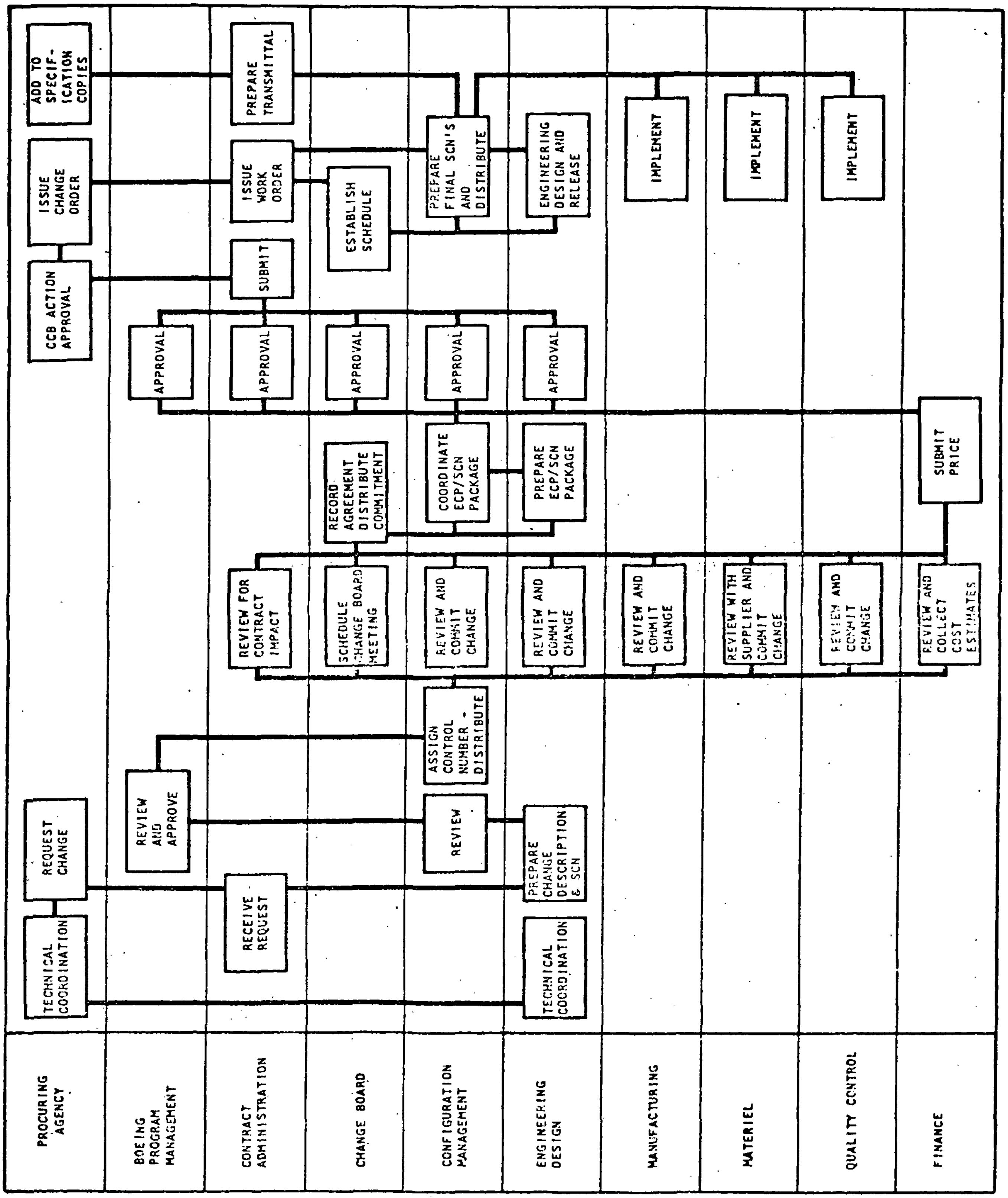


FIGURE 9.2-1: CLASS I CHANGE PROCESSING

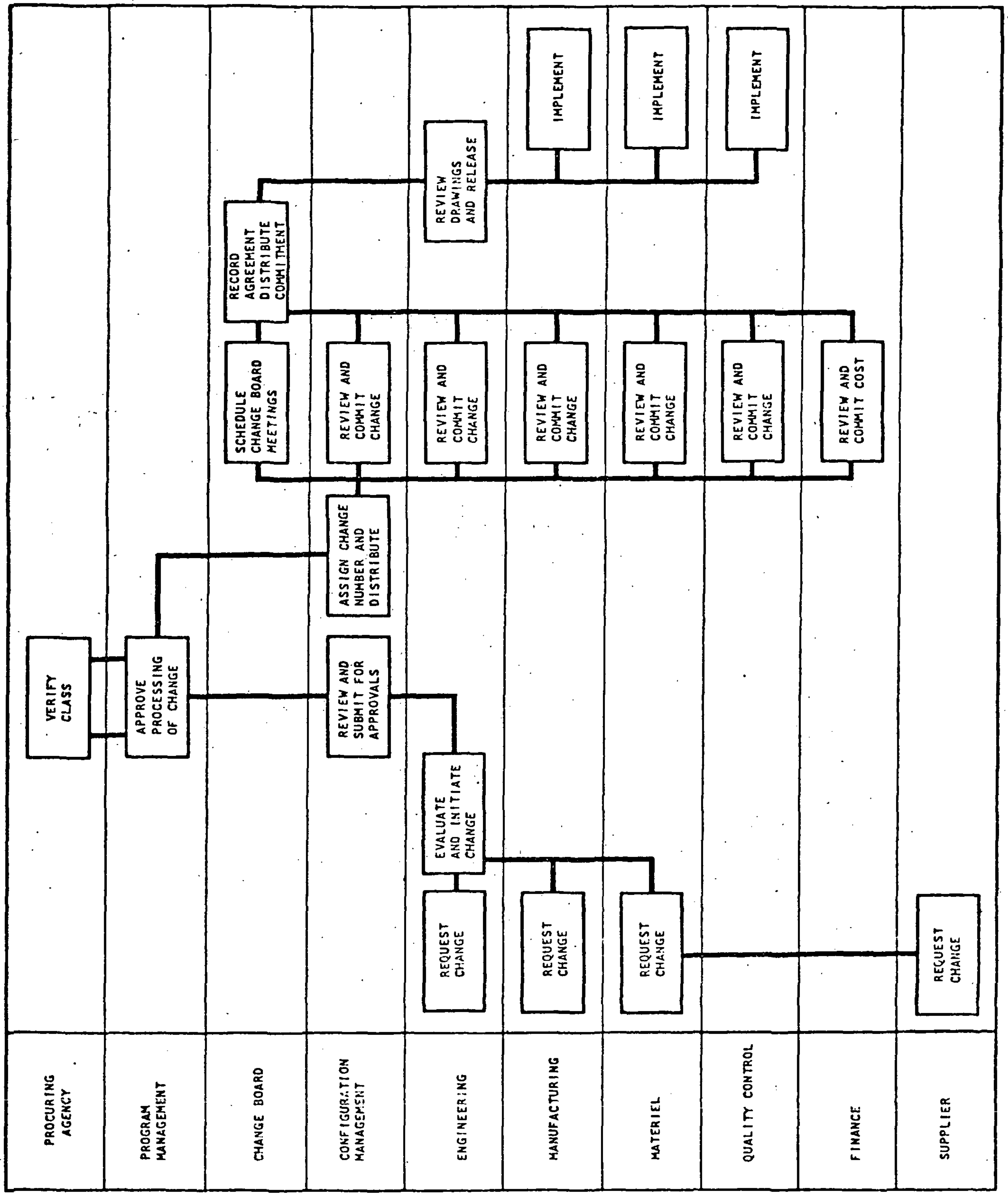


FIGURE 9.2-2: CLASS II CHANGE PROCESSING

The Change Board is chaired by a Change Board Manager reporting to the Project Manager. Planning and scheduling is based on the Change Board commitments and is monitored at the management meetings which include participation of the Configuration and Change Board Managers. This provides current, clear visibility, and monitoring at the management level to assure adequate, proper, and timely change control.

9.2.4 DESIGN REVIEWS AND CIDR

In accordance with established practices, the contractor will conduct in-house design reviews, scheduled prior to drawing release of all spacecraft subsysems. During these reviews the cognizant designers will present their designs, showing the rationale for the selected configuration and method of compliance with all requirements, including reliability and maintainability. The project manager, systems integration, reliability, manufacturing engineering, and related design and staff organizations will participate in these reviews. The agenda for the reviews will include the results of trade studies, critical processes, reliability potential, design margins and possible problem areas. Design review minutes, containing action items and close-out responsibility, will be distributed to affected organizations. The results of reviews will be presented at the CIDR and as part of the Reliability Status information reported on during the Technical Management/Program Status meetings.

A Configuration Item Design Review (CIDR) will be held at the Contractor's facility. Contractor will provide a co-chairman and will conduct the CIDR in accordance with, and with the approval of the Procuring Agency. During the CIDR, the spacecraft baseline design will be presented and will be reviewed, in detail, for compliance with all requirements.

Configuration Management Organization will have the responsibility for preparation and coordination of the agenda(s), design review minutes, and follow-up on action items.

9.2.5 PRE-ACCEPTANCE REVIEW

Contractor will provide and conduct, with the approval of the Procuring Agency, a Pre-Acceptance Review of all his deliverable hardware. Contractor will provide a co-chairman and necessary supplies and services. Configuration Management will provide the following:

a. Coordinated and approved Agenda.

b. Minutes of the Pre-Acceptance Review.

c. Responsibility for follow-up to clear action items.

d. A Master Drawing List, marked to notify the cognizant engineer of outstanding advance drawing change notices (ADCN), which are to be incorporated prior to Pre-Acceptance Review.

e. A Final Master Drawing List and a "Drawing and Data Requirements Complete" (DDRC) summary to Quality Control for review to ensure that all changes are incorporated in the hardware and the data package is in agreement with the latest issue of the drawing.

f. A complete set of up-to-date drawings (no ADCN's) of the hardware.

g. The up-to-date approved System Specification and the up-to-date approved hardware end item specifications, Part I's.

h. Documented Quality Assurance Verification data of the hardware.

Manufacturing will supply a copy of the as-run acceptance test data with completed Quality Control approvals.

9.2.5 CONFIGURATION INDEXING AND ACCOUNTING

The configuration will be documented in accordance with existing practices including the use of USAF record forms or equivalent. Configuration identification numbers comply with the requirements of Exhibit X of AFSCM 375-1. Contractor will continue to use the drawing numbering system established for the Burner II Program. Contractor's standard drawing practices comply with the intent of MIL-D-1000 and MIL-STD-100A. The configuration will be identified at every level of assembly, on every deliverable item, by engineering drawings and specifications.

9.2.5.1 Engineering Release Records. Engineering release records provide all the elements of data required by Exhibit XII of AFSCM 375-1. Contractor maintains configuration accounting records to disclose the configuration status of each end item to maintain proper control and the capability of processing Class I changes.

9.2.5.2 Control Practices. The contractor's practices exceed the minimum standards for control of engineering, manufacturing documentation, and related administrative records. These capabilities are used to control the incorporating of Class I engineering changes in contract end items, to reconcile Engineering Work Authorizations to contract requirements, to verify that released engineering and purchase orders are in accordance with the contract, to assure that engineering design and changes are manufactured and installed as required by released engineering data, and to document engineering change incorporation.

9.2.5.3 M&IRS. As a part of the overall Boeing Configuration Management Plan Boeing uses integrated record system throughout the manufacturing cycle. Upon receipt of distributed drawings, the Manufacturing Engineers prepare and release shop orders for the fabrication, assembly, installation and test sequencing. The format of the shop orders is the Boeing "Manufacturing Integrated Record System." This system provides the definition of the work to be done, the shop to which the work is assigned, the recording of in-process inspections, attachment of all test data and unplanned events, recording of the completion, and provides an inspection record for historical data.

This system provides complete configuration control of the hardware in that it correlates and verifies that the configuration of the hardware, inspection records, and drawings are the same, or records all approved deviations.

In addition to retention by Quality Control of all completed inspection records, Manufacturing maintains records of all shop orders released and completed to assure that all authorized work is in fact completed.

Manufacturing Engineering is made aware of all changes by close working relations with Engineering Design. Since all parts list revision and drawings revision vellums come to Manufacturing Engineering for processing prior to release, a direct control of all change activity is assured. Accurate status of work in process is provided to properly commit changes.

The completed Manufacturing and Inspection Records will contain the data to verify the completion of development, qualification, and production acceptance tests.

The Integrated Record System provides a comparison of released engineering and inspection records to the actual hardware for verification of total compliance with end item top drawing. These records are the Quality Assurance verification of the flight worthy condition of the vehicle at Pre-Acceptance Review and delivery.

9.3 BASELINE CONTROL

Baseline Control is a management technique used to establish a definable point of departure for control of future changes to the system and end item specifications.

9.3.1 SYSTEM REQUIREMENTS BASELINE

The mission requirements baseline is defined by an approved system specification. After approval, the system specification may be changed only by an approved Class I change.

9.3.2 DESIGN REQUIREMENTS BASELINE

The design requirements baseline for end item equipments and approval of Part I of the end item specification is established at the Configuration Item Design Review. The approved Part I may be changed only by an approved Class I change. The design will be reviewed at the same time that Part I of each end item specification is reviewed and approved. The CIDR minutes will contain any agreed changes to be made to drawings and specifications prior to granting approval.

9.3.3 PRODUCT CONFIGURATION BASELINE

The product configuration baseline is defined by released engineering drawing. This baseline is established at the Pre-Acceptance Review. After establishment of the product configuration baseline, all changes to end item specifications and drawings will be prepared and submitted according to the instructions of ANA Bulletin 445.

9.4 ENGINEERING DRAWINGS

Drawings are prepared in accordance with Boeing Drafting Standards Manual PM93A1. These standards comply with the requirements of MIL-D-1000. The Boeing Drafting Standard Manual was developed as the means of ensuring compliance with Government requirements while maintaining the most practical and economical degree of standardization. The Drafting Standards includes drawing requirements, identification requirements, drafting practices, release procedure, drawing changes and quality assurance.

Detail assembly and installation drawings, prepared in accordance with the drafting standards, convert the requirements of the End Item Specification, Part I, into drawings, documents and control specifications. These data are used to define and produce the equipments which make up the system.

Each drawing is assigned a unique drawing number. A master numerical list and master drawing tree list will be maintained to provide ready drawing entry into any level of the system.

All drawings and related data are prepared in accordance with MIL-D-1000 and MIL-STD-100, except data for components procured as standard commercial parts. Such components will comply with commercial drawing practices.

9.4.1 DRAWING INFORMATION

Drawings contain the basic information as required by AFSCM 375-1, Exhibit XII, and the following:

a. Engineering requirements such as quantity, material, dimensions, tolerance, form and finish.

b. Reference to specification and standard requirements for materials, processes, treatments, test methods and procedures.

c. Assembly, test, adjustment and calibration information.

d. Identification marking including part number and serial number effectivities.

9.4.2 DRAWING RELEASE

The drawing release system is designed to maintain control of all drawing release activity beginning with the authorization to proceed with engineering. The Engineering Release Control function maintains a release status record to ensure that all drawings related to the basic design or engineering changes are released as scheduled.

9.4.3 DRAWING REVIEW

The technical review of drawings is accomplished within the Engineering Organization by the design groups affected and by supporting technologies. Engineering management signatures are required to ensure the appropriate technical reviews are accomplished. All assembly and installation drawings

are reviewed for reliability and safety. The nontechnical review for format, legibility and appropriate signatures is accomplished by the Release Control function.

9.4.4 DRAWING CONTROLS

Once a drawing is released, it is placed under rigid control. Approval must be obtained from the Release Control Organization prior to obtaining the drawing original from the vault. An approved change must be in evidence prior to granting this approval.

9.4.5 DRAWING CHANGES

Revisions to released design must be processed by an approved Class I or Class II change. The design may be revised by new drawings, revised drawings, or Advanced Drawing Change Notices (ADCN) or a combination of these. The revision will completely define and illustrate the changes to detail parts, assemblies, and installations and provide new part and assembly numbers, production effectivities, change authority, parts list corrections, and instructions for disposition or rework of superseded parts.

9.4.6 RELEASE SYSTEM

The SS&PS Organization uses a Progressive Release System for new design and extensive design changes. This system provides for the release of engineering in quantity sufficient to permit Materiel to place orders for long lead items and Manufacturing Engineering to develop and implement a Manufacturing Plan on a scheduled basis simultaneously with Engineering Design. The basic engineering design will be released subsequent to the CIDR of each end item.

All drawings and engineering data which pertain to the manufacture and test of the end article are routed through Manufacturing Engineering, Quality Control and Materiel for prerelease coordination to ensure the availability of parts and the producibility of the article to meet schedules. Released drawings and data are distributed to department files for "authorized, validated blueprint" file use.

9.5 SPECIFICATIONS

Boeing will prepare the System and CI specifications to include the total mission definition and requirements to the extent necessary to provide an integrated system. The system specification will include:

- o The use and description of the total system.
- o Performance requirements of the total system.
- o Requirements related to manning, operating, maintaining and logistically supporting the total system to the extent these requirements define or constrain design.
- o The principle interfaces between the spacecraft and the other mission segments with which it must be compatible.

The contract item specification will provide the requirements for performance and operation of the satellite. Part I of this specification, when approved at CIDR will define the hardware requirements baseline. No Part II's of the end item specifications will be prepared or submitted for review and approval. The product configuration baseline will be controlled by the end item top and subordinate drawings. Inspection of the design drawings and hardware and the acceptance test data at preacceptance review confirms the interfaces and hardware compliance. The final confirmation of all hardware interface compatibilities will be established at the launch facility during assembly, test and checkout. After preacceptance review and delivery of the hardware, any change to specifications or delivered hardware is initiated and controlled according to ANA Bulletin 445.

9.5.1 INTERFACE MAINTENANCE

The interface control agreement between the Contractor and any Associate Contractor requires a coordinated and approved interface control drawing, defining the interfaces of contractor and associate produced equipment, which will be incorporated in both the Contractor and Associate Contractor approved specifications. Any proposed changes to these interface control drawings after approval of the specifications, will require separate coordinated ECP's to each specification. The procuring agency will approve each ECP by a change order to each contract. Thus, approved changes will be documented by interface control drawings as a binding agreement on the Contractor and the Associated Contractor.

The ECP forms describing Class I changes to an interface control drawing will be accomplished by a Specification Change Notice (SCN) for each drawing affected. A Specification Change Log (SCL) will list all SCN's for each specification affected by the change. A specification identification index will be maintained to identify all contractor specifications and the approved changes to each.

9.6 SUBCONTRACTOR/VENDOR CONTROL

Subcontractors, vendors and suppliers will comply with the requirements Boeing Document D2-23534, "Burner II General Requirements Document (Supplement to Control Drawing)." Requirements from this document are made applicable through the source or specification control drawing. Compliance with the stated requirements are verified at procurement milestones such as design reviews and first article configuration inspections. Test plan, procedures, reports and drawings are submitted to Boeing for review and approval.

Reproducible copies of this data are received and maintained in Contractor's engineering vault. All or portions of the data may be included in Contractor documents to substantiate qualification of equipment.

Proposed changes must be submitted to Boeing for approval prior to incorporation. After establishment of the supplier product configuration baseline, changes are subject to the Class I and II change procedures. Proposed Class I changes will not be incorporated prior to the approval of the procuring agency. The ECP will be prepared and submitted by Boeing.

10.0 DATA MANAGEMENT PLAN

The data management system used successfully on the SAMSO Burner II/IIA, SESP, and STP programs during the past 10 years will be implemented on the BSRM Program. The data management system recognizes the use of data to define the hardware, verify it meets requirements (both analytically and by test), operate and maintain the hardware and provide visibility for managing the BSRM Program. The matrix of the interrelated documentation controlled by this plan is shown in Figure 10.0-1.

Key ingredients of the data management system are:

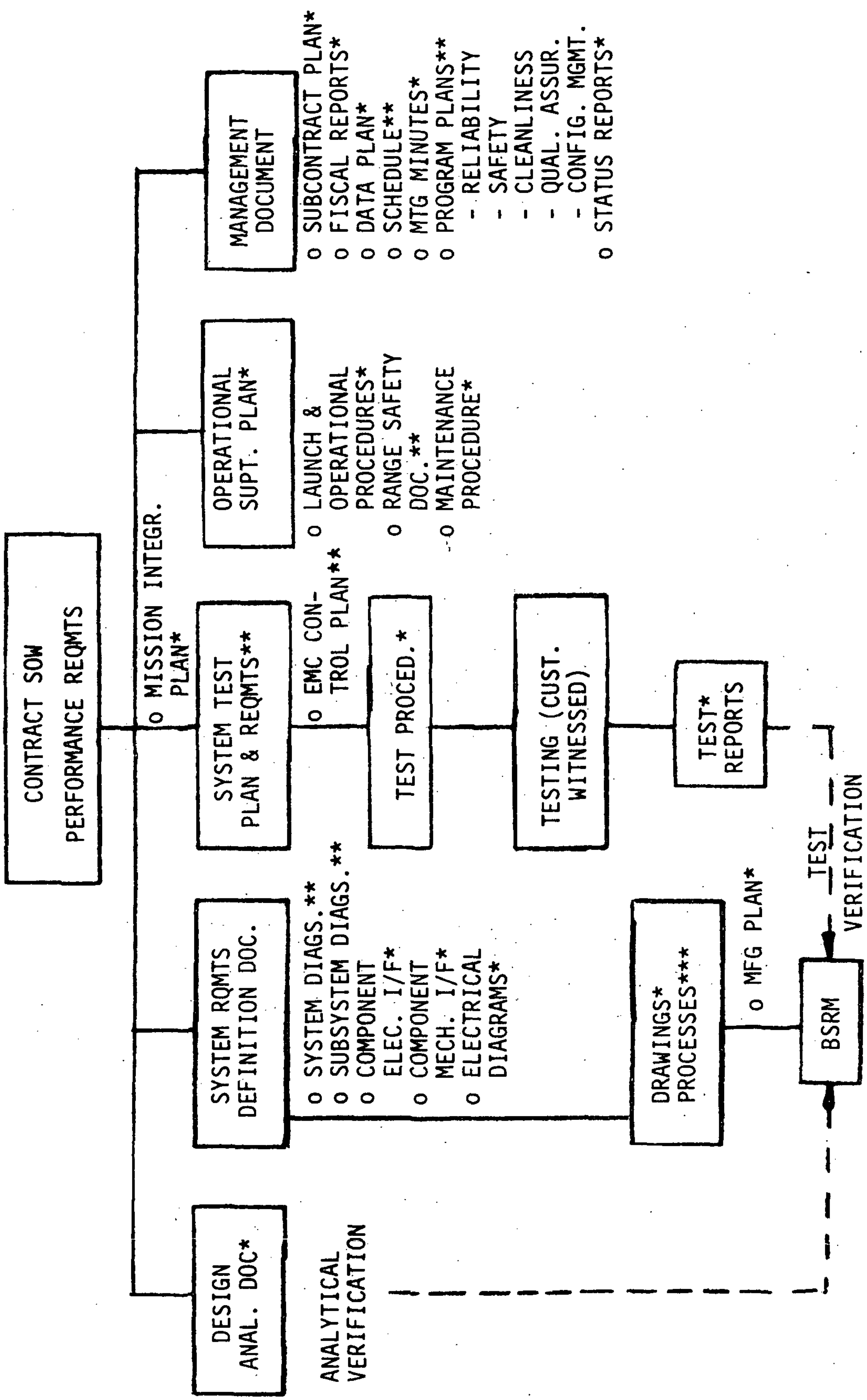
- o Early identification of data requirements across the program, including both deliverable and nondeliverable data.
- o Continuing review of data requirements to preclude the duplication of like data in different data items and to eliminate unnecessary data generation.
- o Total CDRL schedule phasing.
- o Single-point contact on all data matters.
- o Visibility of and coordination with the program schedule and technical status of the program.
- o Complete support of customer data requirements, verified by weekly internal audits of accomplishments and near-term (one month) requirements.
- o Completely documented support of reviews and formal meetings (PDR, CDR, ICWG, project management/program status).
- o Visibility of CDRL status at program reviews with SPO.

10.1 ORGANIZATION AND RESPONSIBILITIES

Data management organization for BSRM Program and its relationship to the company and program organization is depicted in Figure 10.1-1. The responsibilities for each organizational element are also depicted.

The BSRM Data Manager is the single-point contact for data matters. He will be the central authority for CDRL compliance, eliminating the possibility of conflicting instructions and communications flowing between customer and contractor personnel. Each data submittal will be reviewed to verify that the data fulfills requirements. This review ensures that any data activity requiring management attention will be emphasized immediately.

The Data Manager assigns responsibility for each CDRL data item to the appropriate organizational supervisor. CDRL schedule is maintained by Program



*SUBMITTED FOR INFORMATION

**SUBMITTED FOR APPROVAL

***AVAILABLE AT CUSTOMER REQUEST

FIGURE 10.0-1: PROGRAM DOCUMENTATION MATRIX

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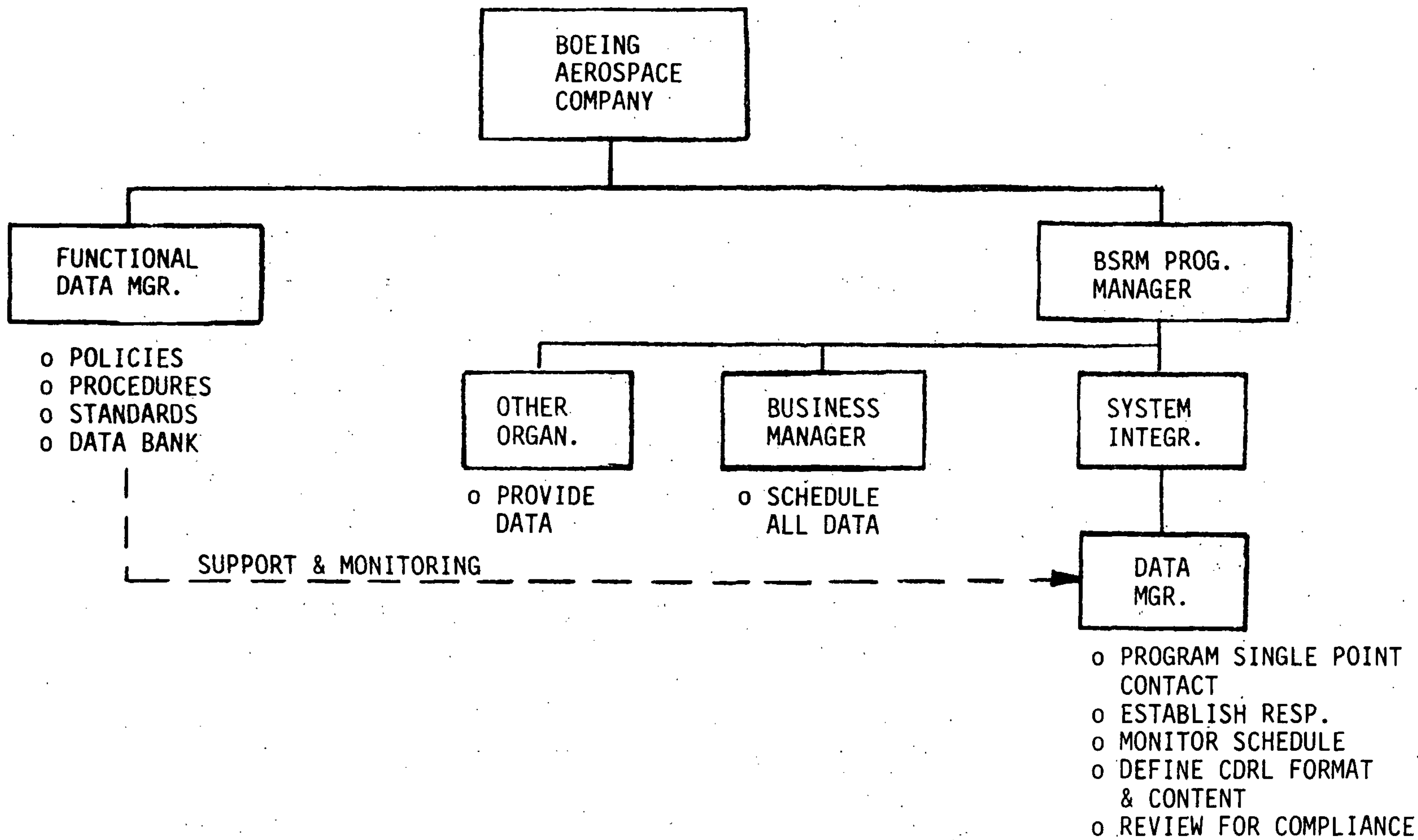

FIGURE 10.1-1: BSRM DATA MANAGEMENT

Planning for visibility by both the Data Manager and the BSRM Program Manager. The Boeing Aerospace Company's functional data manager provides standardized policies and procedures for handling of data, provides information and advice as requested by the program for any unique problems that may arise and audits compliance to recognized company performance standards.

10.2 DATA PROGRAM

Responsibilities and methodology for discharging individual CDRL tasks will be contained in a BSRM CDRL requirements document to be published immediately after contract go-ahead. The document, to be distributed to all BSRM personnel responsible for preparing deliverable data, will contain the following:

- o Instructions for preparing the data, including format, special markings, etc.
- o Standardized interpretations and definitions of data forms.
- o Current contractual CDRL items.
- o Current addresses for exterior distribution of data.

The document will be revised as necessary to provide current information on a timely basis.

Assignment of responsibility for each data item will be made by the Data Manager to the lowest organizational unit supervisor. In conjunction with the Program Planning organization all items are scheduled and performance against schedule is monitored by both the Data Manager and the Program Manager. Prior to transmittal, all data is reviewed by the Data Manager to assure compliance with data requirements.

Boeing practices for format and content of most data have taken into account AFR 310-1. Accordingly, most data to be generated will fall into data categories III and IV. This practice provides a cost effective approach to controlling the data program while still meeting CDRL requirements.

11.0 SUBCONTRACT PLAN

Monitoring and control of the business and technical aspects of subcontracting as described in this document will ensure on-schedule delivery of quality products from suppliers. The Procurement Organization, collocated with all other program elements, manufacturing shops, Quality Control, Program Management and Contract Administration provide for direct communication and control. The general requirements imposed on subcontractors covering quality assurance, reliability, reporting, and documentation ensure visibility at this subcontract level. The relations and involvements of design engineering with the subcontracting function ensures control of subcontract technical detail and end items.

The appropriate Company command media covering all levels of direction from Corporate Policy down to and including departmental procedures are catalogued into a functional guide titled, "Aerospace Group Material Baseline Index." The requirements of MIL-STD-1535 will be imposed on Boeing suppliers via imposing the existing document D180-10127-1, Quality Control Requirements for Boeing Suppliers. Specific contractual requirements such as the requirements for registered component control will be imposed on affected suppliers by additional special notes on their purchase contracts.

11.1 MATERIEL ORGANIZATION RESPONSIBILITIES

A Materiel Manager will be assigned to the BSRM program to act with authority in procurement matters. He will participate in all management meetings. He will be exposed to the same direction and philosophy that the other members of BSRM program management receive. He will coordinate directly with the managers of each line organization providing support to his subcontractors and in a like manner, provide subcontractor reports and information directly to the appropriate managers. He will hold regularly scheduled review meetings with the Program Manager to ensure he is constantly apprised of subcontract status and to keep himself aware of customer concerns. He will be supported by an organization dedicated to subcontract management physically located in the program area.

Boeing will emphasize the importance of communication between ourselves and our subcontractors during all phases of the program. Face-to-face discussion between top level management will be used to emphasize crucial program points. Regular management meetings will include the following:

- Boeing Aerospace Company management will visit subcontractor management on site at appropriate times to promote an initial and continuing high level of interest in support of the program.

- The Materiel Manager will maintain continuous contacts with the subcontractor's Program Manager and Contracts Manager to assure himself of the subcontractor's progress. He will take a personal part in motivating the subcontractor and in resolving any developing problems.

So that all levels of management are properly aware of status on all critical items, the Procurement Manager coordinates meetings and other communications with both Boeing and Customer Management. Notices of all scheduled meetings are routed and definite rosters of attendees established. To ensure that the Materiel Manager has firm control of his subcontracts, all contracts will be coordinated on a prior basis.

11.2 PROCUREMENT MANAGEMENT

11.2.1 MAKE-OR-BUY

The requirement for procurement action originates with the Make or Buy Committee, resulting in the establishment of subcontracts or the placement of less formal categories of purchase orders. The Make or Buy Committee for the BSRM program will be established by the Program Manager and represents Project Engineering, Materiel, Manufacturing, Quality Control, Facilities, and Business Management.

The Make or Buy activities are in accordance with the provisions of Make or Buy Guide D2-121359-1. The formal system for regulating and controlling Make or Buy decisions is described in this document. These decisions will be reviewed by the Program Manager and Boeing Management. The following criteria are considered in determining the Make or Buy structure.

- o Design sensitivity of the item (firmness of specification and potential impact on other items).
- o Industry costs versus in-house costs.
- o Industry capability versus in-house capability.
- o Existence of qualified equipment from previous programs.
- o Benefit to customer through employment of specially qualified sources.

The basis for all Make or Buy decisions will be made available for Customer review upon request.

11.2.2 SUBCONTRACT TYPE

The selection of subcontract type is recognized as a major factor in determining the effectiveness of a Boeing/Subcontractor relationship. It is a primary objective to achieve the lowest ultimate cost consistent with quality and delivery requirements. It is Boeing's objective to use firm fixed price subcontracts in the procurement of BSRM purchased equipment.

11.2.3 BIDDERS LIST

Proper selection of bidders for the various hardware and raw material items is critical to the success of any program. The bidders list consists of those who have produced and qualified similar hardware and from contacts made during the preproposal, proposal and the initial design phase. Potential sources are also obtained from the Boeing Supplier Performance Evaluation and Report (SPEAR). The SPEAR report is a summary of prospective bidders past performance on Boeing programs. Minimum considerations for potential suppliers include:

- o Previous experience in producing space proven hardware equal to or better than that required.

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- o Boeing's experience and subsequent knowledge of the supplier quality, technical, producibility and management capability.
- o Financial capability to sustain costs through period of contract. Progress payments will be considered if supplier requests and his accounting system meets all requirements for adequate monitoring.
- o Full compliance with all equal opportunity policies.
- o Minority business must be given full consideration if qualified.

11.2.4 REQUEST FOR PROPOSAL

The first formal contact with potential sources is through the Request for Proposal. This procurement package is thoroughly reviewed by a source evaluation committee to assure all requirements are clear and unambiguous, redundancies are eliminated, and all prime contract flow down terms and conditions are included.

11.2.4.1 Design Criteria. Most of the components in the BSRM program will be space-flight-proven hardware from either previous Boeing or other successful projects. The following priority sequence has been established for design selection.

(a.) Equipment previously qualified to a Boeing source control document.

(b.) Shelf hardware to a vendor part number which without modification or qualification testing will meet our environment, quality, and mission objectives.

(c.) Same as above except needing slight modification to meet BSRM mission requirements. A fact sheet covering the minimum criteria is prepared by Boeing Engineering and included in the subcontract Request for Proposal.

11.2.4.2 Risk Analysis. Every component and subsystem of the spacecraft is analyzed to ascertain and identify critical risk items whose failure to perform as required would jeopardize the spacecraft mission. Once these critical risk items are identified, an evaluation board consisting of Engineering, Quality Control, and Materiel will decide which elements of this plan, and what degree of application, will be assigned to each subcontract based on the level of risk.

Risk assessment will be based on an evaluation of the following elements:

(a.) Cost. Cost risk is directly related to the complexity of the device and the performance of the selected subcontractor during the extent of the contract. Cost risk will be minimized by utilizing firm fixed subcontracts made possible by the extensive use of off-the-shelf hardware. Strict change control will be imposed to prevent costly add-ons to fixed price contracts.

(b.) Schedule. Schedule adherence is one of the most critical aspects of the subcontract tasks and will, if not properly controlled, have an important effect on program costs. Past experience of good schedule performance will be a deciding factor in subcontractor selection. If a subcontractor gets into schedule difficulty, the regularly scheduled surveillance program will be supplemented to increase visits by appropriate Boeing team members to help that supplier get back on schedule.

(c.) Technical. The Engineering subsystem managers will participate in and be instrumental in the selection of high-risk components from a technical standpoint. This list will be minimized by judicial application of our original design objectives. Technical risk assessment is based on criticality, complexity, state-of-the-art design objectives, and available experienced suppliers.

Each potential supplier will be asked to submit his own risk analysis to be used by Boeing Engineering in making a comprehensive risk assessment.

11.2.4.3 Potential Problems/Solutions. Component part procurement at the subcontract level has been a major schedule hazard during similar satellite programs, and the projected business environment does not indicate any improvement for the period of time for the BSRM program. The following disciplines will be implemented to minimize component part shortages that might affect schedules or cost.

- o Basic design policy selects equipment not requiring extensive design or development built to an existing vendor part number with components similar to subcontractors standard line.
- o Subcontractor will be authorized to order long lead items early in the program.
- o Boeing will verify the selection of components most likely to be in stock or relatively short lead time acquisition.
- o Parts will be furnished from Boeing's assets if subcontractor cannot procure in time to support the schedule. Fixed price contracts will be adjusted accordingly.
- o Boeing will stay alert of second tier subcontractor problems and assist suppliers when necessary.
- o Boeing purchasing specialists will help locate sources to support subcontractors.

11.2.4.4 Proposal Evaluation. An analysis and evaluation of supplier proposals is necessary whether the proposal is from a single source or is a result of competitive bidding. The evaluation includes a thorough review of the technical, cost/price, and management proposals. Personnel performing the analysis are the Source Evaluation Committees established for each procurement item.

(a.) The Materiel Manager, Engineering, Quality Control, and Manufacturing personnel evaluate the technical proposals on the basis of how well the proposer understands the design, specifications, statement of work, manufacturing, and quality requirements. Thorough probing is required to determine the adequacy of the technical solution to performance and verification requirements, and in other areas such as identification of risks; exceptions to the statement of work; alternate solutions; consideration of manufacturing, test and operational problems; and understanding the end-use of the procured item.

(b.) The cost proposal from subcontractors is reviewed by cost analysts from the Materiel and Finance organizations. These analysts review the proposals for completeness of cost breakdowns and supporting data. On critical procurements, fact-finding sessions are conducted at the subcontractors' plants. The analysts ensure that the most current data is obtained complying with Public Law 87-653 requirements. If necessary, Boeing also requests audit assistance from the Defense Contract Audit Agency.

(c.) The Management analysis and evaluation determines whether a supplier, who may have the test technical solution and price, can manage the job. Some of the management criteria Boeing evaluates are:

- o Subcontractor schedules for compatibility with program schedules and realistic in view of the subcontractor's work-load projections.
- o Adequate management and controls applied by the subcontractor for internal administration of the subcontract.
- o The potential subcontractor's quality control organization, policy, standards, facilities, and methods to control rejected materials, as well as his records system.
- o The subcontractor evidence of configuration management procedures for the type of work covered, including change control.
- o The subcontractor's ability to provide adequate cost/schedule performance data.
- o The subcontractor's compliance with the subcontract terms and conditions, such as Small and Minority Business and New Technology.

Source surveys are conducted by the evaluation committee to ensure that the subcontractor's existing technical, production and business systems are capable of performing to contract requirements. A survey schedule will be established by joint action of Materiel, Quality Control, Engineering and Manufacturing. Preliminary surveys, where deemed necessary to protect program schedule, will be made during the evaluation period. Surveys will be planned to permit the survey team to take advantage of geographical groupings and minimize travel costs.

Boeing preaward survey of suppliers of critical components, designated as "registered components", will enable technical review and assessment of the proposed manufacturing and processing techniques to be used during production. Information will be furnished to the supplier in advance of the preaward survey to ensure availability of manufacturing and inspection steps for Boeing review and approval.

Boeing has assisted suppliers of critical hardware on prior programs to prepare similar data for analysis of critical processes, identifying the general manufacturing step involved (i.e., chem milling, plating, welding, bonding, etc.), and methods used for examination. The supplier will be required to include in the data, or as an attachment thereto, the specific packaging and preservation methods to be used and the handling and transportation requirements where these are required. Subcontractor format will be acceptable provided the necessary information is included.

11.2.5 SUBCONTRACT MANAGEMENT AND CONTROL

Once sources have been selected and subcontracts negotiated, subcontractors will be monitored to ensure that they meet their contractual requirements technically, economically, and on schedule. Boeing specifies subcontractor reporting requirements as necessary to ensure compliance with prime contract requirements and to ensure visibility and performance measurement. Boeing tries to use the system the supplier uses internally to manage his program. This approach ensures minimum development of unique data consistent with good management visibility and control. Requirements of the prime contract that must be made a part of our subcontract packages are identified and incorporated into our negotiated subcontracts.

11.2.5.1 Registered Components. Registered components are defined as critical items. A critical item can be considered as a subsystem, item of equipment, or component that is vital to the proper performance of the systems and whose failure may seriously impair or cause complete failure of the systems. Practical examples of items requiring special consideration include unproven items, advanced state-of-the-art items, items requiring significant design work, items determined to be high risk and high value, or high reliability items. The above definition will be applied to the BSRM design in accordance with the following ground rules:

- o Functionally redundant items are not registered.
- o Items with predominant failure modes that result in "mission acceptable degradation" are not registered.
- o Off-the-shelf items that are flight-proven and qualified to BSRM environments are not registered.

On subcontracts for registered components, Boeing establishes a team of experts who coordinate in directing the activities of the subcontractor and in resolving any problems that occur. Their primary task is to provide a real time interface between the subcontractor and the program and verify that all requirements are met in a timely and cost effective manner. This team consists of the responsible buyer with assigned specialists from Engineering, Quality Control, Finance and support functions of Materiel. Specific tasks to be accomplished include:

- o Assist the subcontractor in the interpretation of Boeing requirements as set forth in contractual documents and specifications.
- o Assist the subcontractor in identifying and obtaining the required inputs from Boeing, i.e., data approvals, test approvals, government furnished equipment, etc.
- o Review and/or approve all critical lower tier procurements placed by the subcontractor.
- o Review and monitor data, information, and milestones within their respective areas to ensure that the subcontractor is performing adequately to satisfy contract objectives.
- o Maintain an effective and aggressive communication with respective subcontract counterparts pointing out areas of potential problems affecting quality, product design, costs, schedules, or any other factors relating to the contract.
- o Monitor and report weekly on subcontractor progress to the program manager. Provide early identification of problems and assist in resolution.
- o Assist the subcontractor in preparing for porgram reviews, design reviews, and technical interchanges, ensuring that all contract data requirements are met.
- o Monitor the subcontractor's approved Quality Assurance program for compliance.
- o Conduct selected mandatory inspections on in-process hardware.
- o Monitor configuration management practices and ensure compliance with subcontract requirements.
- o Accomplish the initial review and recommendations of subcontractor test procedures. Provide approval of restarts found necessary during test, thus eliminating cost and schedule slides inherent in a normal approval cycle.
- o Witness developmental, qualification, and acceptance testing from both quality and technical viewpoints. Review and accept or reject test data, and participate in the review and acceptance of deliverable hardware.

11.2.5.2 Configuration Management. Subcontract requirements for supplier configuration management are defined in the subcontract statement of work, the supplier data requirements list, and as applicable, supplier data descriptions. A significant element is required for control and accountability of registered components.

Registered components will be identified by a notation on the engineering drawing. When registered components are procured, the purchase contracts will require the supplier to provide detailed manufacturing and processing plans to be used during manufacturing for review and approval for production commences. When approved, the supplier will not be permitted to deviate from the plan until Boeing has reviewed and approved the proposed change.

11.2.5.3 Changes and Change Control. The control of changes is one of the most important aspects of subcontract management. A change that may seem insignificant with respect to the specification may result in excessive increased costs and serious schedule disruptions if not properly recognized and handled correctly. The effective control of changes requires constant attention to three basic aspects of the problem:

(a.) The necessity and priority of any changes proposed by either the contractor or the subcontractor will be coordinated between the procurement manager and the subsystem manager and reviewed by the Program Change Board, which includes representatives from Materiel, Engineering, Program Control, and other concerned organizations. The primary purpose of this review is to keep both the number of changes and their cost and schedule effects to an absolute minimum consistent with the success of the program.

(b.) Coordination between the Materiel manager and the subcontractor determines the timing of the change to achieve the minimum adverse effect on costs and production schedules.

(c.) Pricing of changes will receive the same close attention as an original procurement of the same magnitude. The Materiel Manager will use subcontractor data, in-house estimates, contractor or Government audit and planned negotiation to ensure a fair and reasonable price. Emphasis will be placed on negotiating change proposals promptly and definitizing the subcontract without delay.

Once the necessity for a contractor-initiated change has been determined by the Program Change Board, the buyer must immediately forward the technical description to the supplier of the affected equipment, requesting him to advise concerning the cost and schedule effect of implementing it in accordance with the priority assigned. On high-priority changes, it may be necessary to tell the supplier to proceed with implementation prior to receiving a firm, substantiated cost proposal. He will be asked to furnish immediately a "not-to-exceed" budgetary price that can be sued to determine the effect on subsystem budget until a firm price can be negotiated.

Source Quality Control will be responsible to ensure that the supplier has complied with change effectivity requirements and that configuration records are complete and accurate before the subcontracted hardware is shipped.

11.2.5.4 Quality Control. Quality Control is responsible for all quality activities associated with procured items from the buy decision through Boeing acceptance of the item at the subcontractor level or upon acceptance of its shipping desgination. When a contract has been approved, the supplier will not be permitted to deviate from the plan until Boeing has reviewed and approved the proposed change.

(a.) Quality Control personnel participate as members of management teams and source selection boards in selecting qualified sources and ensuring that selected subcontractors possess adequate facilities, systems, and configuration management capabilities for producing quality products and services.

(b.) Quality Control evaluates supplier proposals for adequacy of Quality Assurance provisions and responsiveness to proposal requirements. Suppliers are ranked in order of preference and data provided to the board chairman. Objective evidence of evaluations will be maintained on file.

(c.) The subcontractor requirements is the existing provisions contained in Quality Control Requirements for Boeing Suppliers, Document D180-10127-1, and special purchase order note resulting from MIL-STD-1535.

(d.) Quality Control participated in the preaward surveys of prospective suppliers. Supplier quality system surveys will be conducted prior to start of manufacturing to ensure compliance with D180-10127-1 and MIL-STD-1535. A system is maintained for the authorization and listing of approved procurement sources. The supplier is resurveyed annually to determine his continued ability to satisfy his contractual quality requirements.

(e.) Purchase documentation will be reviewed prior to release to verify the inclusion of requirements for qualifications or approvals, configuration accountability provisions, and customer inspections unique to the individual procurement, ensuring that appropriate documentation is submitted to the customer for review and approval.

(f.) Source Control engineers will provide technical review of specification control drawings and supplier drawings to ensure adequacy of quality requirements. Comments will be provided to engineering and follow-up accomplished to verify resolution. Quality Control engineering personnel shall participate in preliminary design review, critical design review and first article inspection at supplier locations.

(g.) Surveillance work plans to be initiated by quality planning for use by field quality representatives. The plans will document the control points necessary to check that the supplier is adhering to product, system, and process requirements. The hardware inspections, data review, and test observances and their frequencies will be outlined. The work plans provide area for entries by the representative for objective evidence of compliance.

(h.) Registered Components will be identified by a notation on the engineering drawing. The purchase contracts require the supplier to provide detailed manufacturing and processing plans to be used during manufacturing for review and approval before production commences.

11.2.5.5 Program Reviews. Frequent program reviews are conducted at the subcontractor's facility to assess program progress, problem areas encountered, corrective action taken or anticipated, status of action items, costs, and other related subjects. Program reviews are attended by the Materiel Manager and selected program personnel. These reviews serve to supplement reports and to maintain controls to ensure total contract and program compliance. Critical items are reviewed on an established schedule. The customer will be invited to attend these review meetings.

11.2.5.6 Premanufacturing Surveys. Premanufacturing surveys on critical items are conducted after CDR to ensure that subcontractors are prepared and understand engineering and manufacturing requirements, processes, and quality plans and procedures. These surveys are conducted by qualified management and technical personnel from the program or other Boeing locations as designated by the Program Manager.

11.3 OTHER PROCUREMENT MANAGEMENT FUNCTIONS

11.3.1 ACCOUNTABILITY - GOVERNMENT PROPERTY

The accountability for tools, special test equipment, materials, and parts furnished or owned by the Government is one of the subcontractor's responsibilities. The subcontract contains provisions to ensure compliance with these requirements. Controls include periodic audits of contractor and supplier records and reports. Boeing also performs a physical inventory, inspection of conditions, markings, and storage arrangements. Surveillance is conducted in close liaison with the program finance and quality control organizations.

11.3.2 SUPPORT SERVICES

Support the total procurement system, a support service organization initiates and maintains the necessary command media to verify that our subcontracting procedures are in compliance with company policies and Government regulations. This organization prepares reports on small business, minority business, geographic distribution of project dollars, Defense Material Services, New Technology Reports, and GFE Accountability and Status Reports as required by NASA.

11.4 CUSTOMER REPORTING

Subcontractor status reporting will be accomplished on those "critical" subcontractors selected for monthly reporting as mutually agreed upon by the customer and Boeing. Existing formats for reporting subcontractor surveillance will be used. The reports are based on the results of planned team visits to supplier plants, quality surveillance at supplier plants, monthly reporting from the supplier, PDR's and CDR's at the supplier facility, telecon record reporting, and CDRL submittals of test plans, procedures and reports.

11.4.1 HIGH RISK ITEM SURVEILLANCE

Registered Critical components require special supplier surveillance especially from a schedule standpoint. Recent Boeing Space Test Program experience suggests surveillance of subcontractor schedules is desirable when subsystems require burned in peice parts (resistors, relays, capacitors, etc.).

12.0 BSRM PROGRAM SCHEDULE.

A preliminary master schedule for the BSRM is shown in Figure 12.0-1. The 3-axis or spin stabilized versions can be developed within the same time span.

The preliminary schedule conforms to the following groundrules:

- o The BSRM program will be conducted in accordance with the plans outlined elsewhere in this document.
- o The BSRM test program details will be as defined in D180-18450-2, Section 4.2.

Long-lead items are procured within 15 days of go-ahead by release of procurement specifications. Specs available from other programs will be released for BSRM. Since all components are flight qualified, no extensive procurement specification preparation is required.

For multiple unit buys, Boeing will procure all equipment items at one time. Delivery of each BSRM in a multiple unit buy will be made at seven month intervals to prevent conflict in the use of test AGE and GHE. Also, field processing personnel are the same individuals conducting the factory testing and would not be available to support a factory BSRM during launch preparation of another vehicle.

The BSRM vehicles could be put into storage after DD250 instead of immediately going into launch processing as demonstrated on the Boeing S3 program. Condensed System Performance Tests would be conducted during the storage period at three month intervals and the Acceptance Test repeated at call-up prior to shipment to the launch site. Additional program costs would be incurred for this approach.

The BSRM test program is defined in detail in Section 4.0 of this document. Figure 12.0-2 shows a typical test schedule. Thermal-vacuum tests on the first vehicle only will require an additional 18 days not shown on the figure. The use of existing AGE, GHE and software with the proven Boeing Mobile Test Lab provides high confidence in meeting the proposed test schedule.

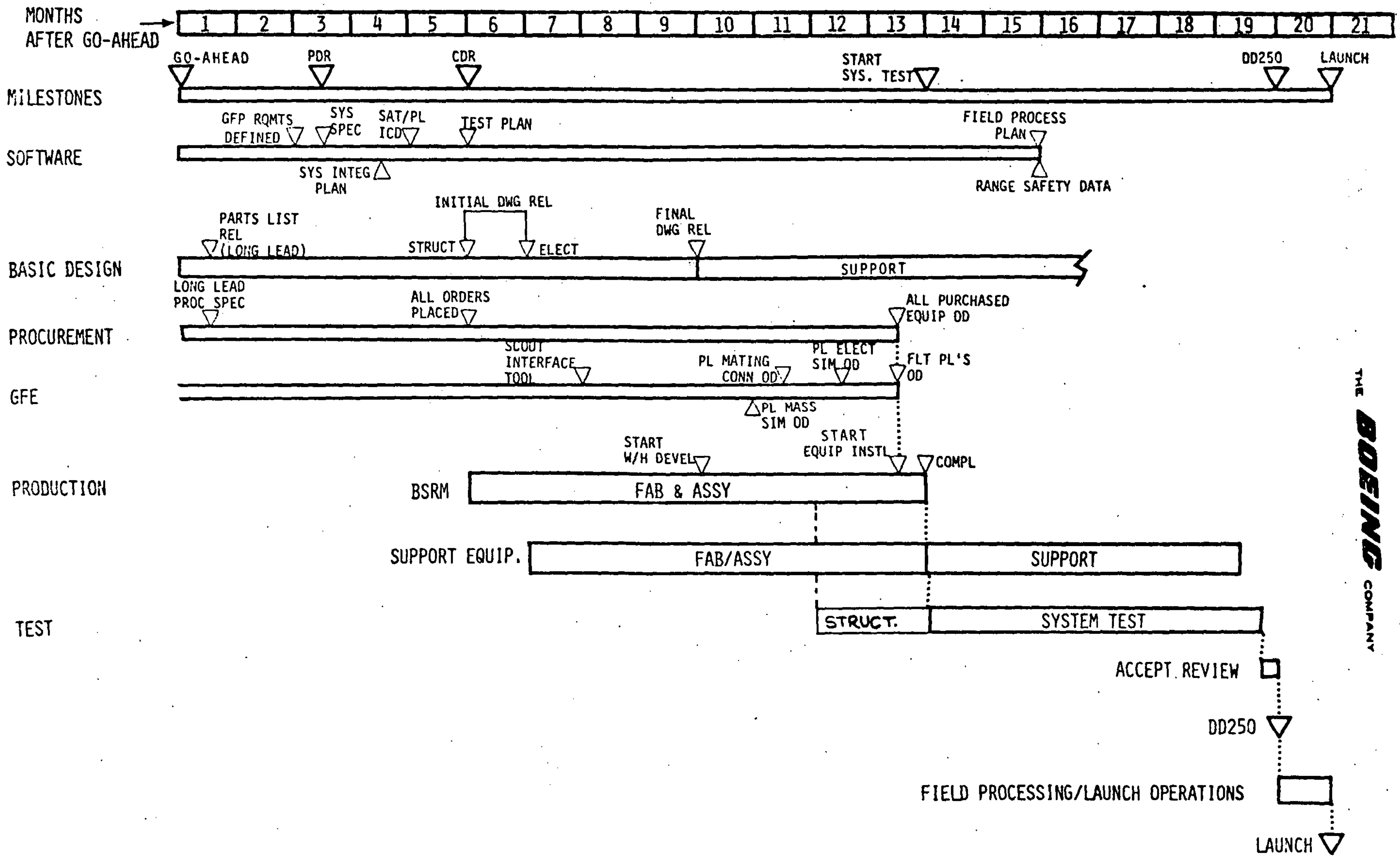

FIGURE 12.0-1: BSRM MASTER SCHEDULE

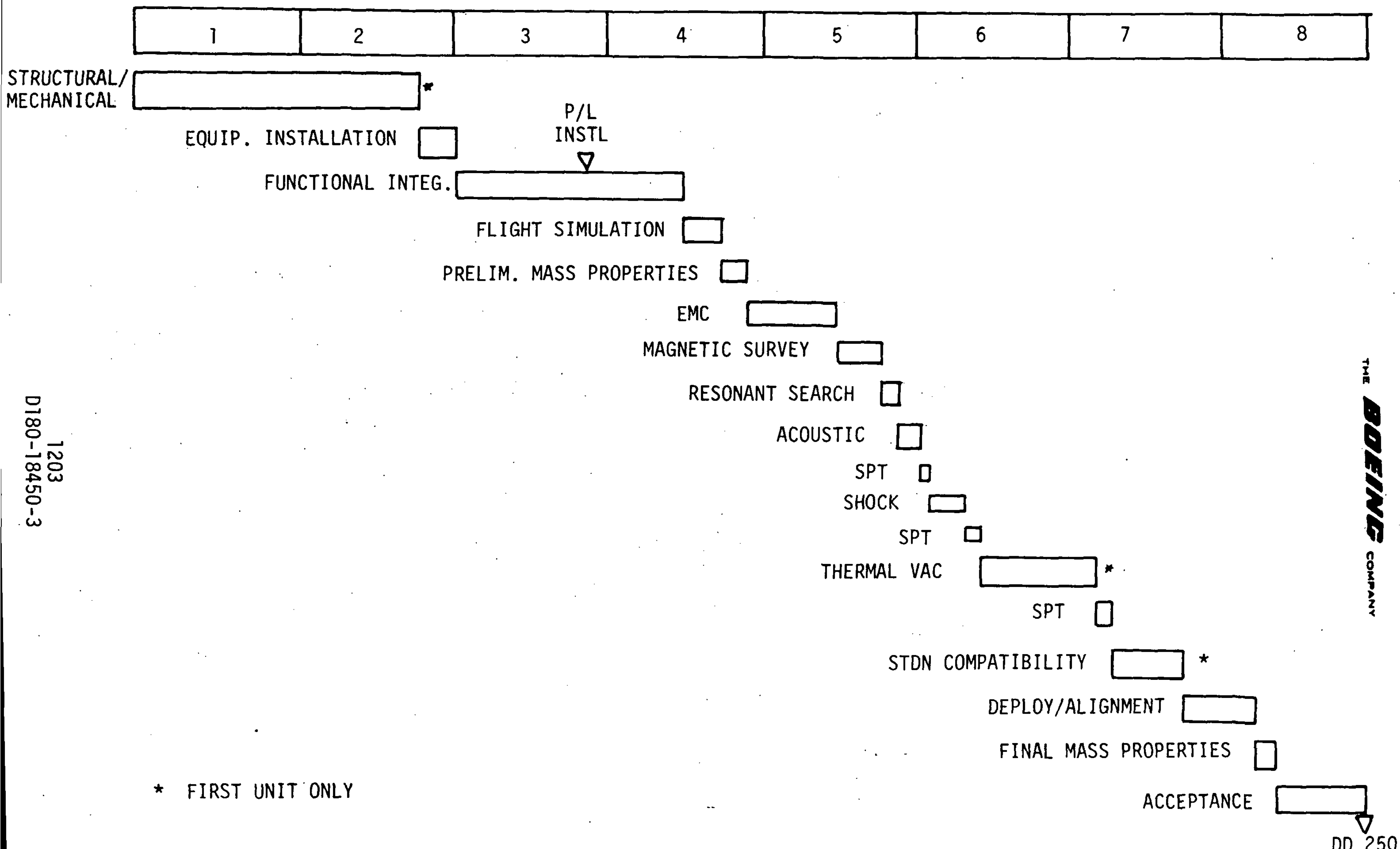

FIGURE 12.0-2: TYPICAL TEST SEQUENCE AND SCHEDULE